



Environmental Group

**Operable Unit 1
Remedial Investigation Report
for the Ventron/Velsicol Site,
Wood-Ridge/Carlstadt,
New Jersey**

Volume 1 of 4
Remedial Investigation Report



Prepared for

Velsicol Chemical Corporation
Rosemont, Illinois

Morton International, Inc.
Chicago, Illinois

Certification Statement

I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant civil penalties for knowingly submitting false, inaccurate, or incomplete information and that I am committing a crime of the fourth degree if I make a written false statement which I do not believe to be true. I am also aware that if I knowingly direct or authorize the violation of any statute, I am personally liable for the penalties.

For Morton International, Inc.

By:

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6-16-04

Date

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Prepared for

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Contents

Volume 1	<u>Page</u>
List of Figures	viii
List of Tables	xii
List of Acronyms and Abbreviations	xiv
1.0 Introduction	1-1
1.1 Purpose and Organization	1-2
1.2 Site Description	1-5
1.3 Site History	1-7
1.4 Substances of Potential Concern	1-9
2.0 Field and Laboratory Investigations	2-1
2.1 Phase I Surface Soil Investigation	2-5
2.1.1 Onsite Surface Soils	2-5
2.1.2 Offsite Surface Soils	2-6
2.2 Phase I Subsurface Soil Investigation	2-7
2.2.1 Geophysical Survey	2-7
2.2.2 Test Pits	2-9
2.2.3 Soil Sample Collection and Analysis	2-10
2.3 Phase I Hydrogeological Investigation	2-11
2.3.1 Groundwater Surface Elevation Measurements	2-11
2.3.2 Aquifer Parameter Tests	2-13
2.3.3 Sample Collection and Analysis	2-14
2.4 Phase I Leachate/Seep Sampling	2-14
2.4.1 Objective	2-14
2.4.2 Approach	2-15
2.4.3 Deviations from the Work Plan	2-15
2.5 Phase I Surface Water and Sediment Investigation	2-15
2.5.1 Objectives	2-15
2.5.2 Approach	2-16
2.5.3 Deviations from the Work Plan	2-16

	<u>Page</u>
2.6 Phase I Wetlands Investigation	2-17
2.6.1 Objectives	2-17
2.6.2 Approach	2-17
2.6.3 Deviations from the Work Plan	2-17
2.7 Phase I Air Sampling	2-18
2.7.1 Objective	2-18
2.7.2 Approach	2-18
2.7.3 Deviations from the Work Plan	2-19
2.8 Phase I Hazardous Substance Inventory	2-19
2.8.1 Objectives	2-19
2.8.2 Approach	2-19
2.8.3 Deviations from the Work Plan	2-20
2.9 Phase I Topographic and Location Survey	2-20
2.9.1 Objectives	2-20
2.9.2 Approach	2-20
2.9.3 Deviations from the Work Plan	2-20
2.10 Phase I Cultural Resources Investigation	2-21
2.10.1 Objective	2-21
2.10.2 Approach	2-21
2.10.3 Deviations from the Work Plan	2-21
2.11 Phase IA Cutoff/Containment Wall Investigation	2-22
2.11.1 Objectives	2-22
2.11.2 Approach	2-22
2.11.3 Deviations from the Work Plan	2-22
2.12 Phase IA Field Investigation	2-23
2.12.1 Objectives	2-23
2.12.2 Approach	2-23
2.12.3 Deviations from the Work Plan	2-26
2.13 Supplemental Warehouse Evaluation Study	2-27
2.13.1 Objectives	2-27
2.13.2 Approach	2-27
2.13.3 Deviations from the Work Plan	2-28

	<u>Page</u>
3.0 Physical Characteristics of the Site	3-1
3.1 Topography and Surface Features	3-1
3.2 Climate and Meteorology	3-2
3.3 Geologic Setting	3-2
3.4 Surface and Subsurface Soils	3-6
3.4.1 Developed Area	3-6
3.4.2 Undeveloped Filled Area	3-6
3.4.3 Marsh Area	3-7
3.5 Surface Water Hydrology	3-8
3.5.1 Surface Water Drainage Network	3-8
3.5.2 Surface Water Elevation and Tidal Action	3-8
3.5.3 Frequency and Extent of Flooding	3-9
3.6 Groundwater Hydrogeology	3-9
3.6.1 Regional Hydrogeology	3-9
3.6.2 Site Hydrogeology	3-10
3.6.3 Groundwater Classification	3-15
3.7 Ecological Description	3-15
3.7.1 Vegetation Cover Types	3-15
3.7.2 Wildlife	3-16
3.7.3 Habitat Quality and Resource Value to Biological Communities	3-17
3.7.4 Wetlands Functional Assessment	3-20
3.7.5 Summary	3-24
3.8 Demography and Land Use	3-24
4.0 Nature and Extent of Contamination	4-1
4.1 Soils	4-2
4.1.1 Onsite Surface Soil Analyses	4-2
4.1.2 Onsite Subsurface Soil Analyses	4-5
4.1.3 Offsite Soil Analyses	4-12
4.1.4 Diamond Shamrock/Henkel Soil Analyses	4-14
4.2 Groundwater	4-16
4.2.1 Mercury	4-16
4.2.2 Other Metals	4-18

	<u>Page</u>
4.3 Leachate/Seeps	4-21
4.3.1 Mercury	4-22
4.3.2 Other Metals	4-22
4.3.3 Organic Compounds	4-24
4.4 Surface Water	4-24
4.4.1 Mercury	4-24
4.4.2 Other Metals	4-26
4.4.3 Organic Compounds	4-26
4.5 Sediment	4-27
4.5.1 Mercury	4-27
4.5.2 Other Metals	4-28
4.5.3 Organic Compounds	4-31
4.5.4 PCB Aroclors®	4-31
4.6 Air Sampling	4-32
4.7 Hazardous Substance Inventory	4-33
4.8 Supplemental Warehouse Evaluation	4-35
4.9 Chemical Data Quality Assessment	4-35
5.0 Transport and Fate of SoPCs	5-1
5.1 Potential Migration Pathways	5-1
5.1.1 Soil, Groundwater, and Seeps	5-2
5.1.2 Surface Water and Sediment	5-7
5.1.3 Air	5-8
5.1.4 Summary of Potential Sources and Migration Pathways	5-8
5.2 Mercury	5-9
5.2.1 Behavior of Mercury in the Environment	5-10
5.2.2 Soil, Groundwater, and Seeps	5-12
5.2.3 Surface Water and Sediment	5-15
5.2.4 Air	5-19
5.3 Other Metals	5-19
5.3.1 Soil, Groundwater, and Seeps	5-19
5.3.2 Surface Water and Sediment	5-23
5.3.3 Air	5-24

	<u>Page</u>
5.4 SVOCs and PCBs	5-25
5.4.1 Soil, Groundwater, and Seeps	5-25
5.4.2 Surface Water and Sediment	5-26
5.4.3 Air	5-28
5.5 VOCs	5-28
5.5.1 Soil, Groundwater, and Seeps	5-28
5.5.2 Surface Water and Sediment	5-29
5.5.3 Air	5-29
6.0 Human Health Risk Assessment	6-1
7.0 Ecological Risk Assessment	7-1
8.0 Summary and Conclusions	8-1
8.1 Summary	8-1
8.1.1 Nature and Extent of Contamination	8-1
8.1.2 Transport and Fate of SoPCs	8-2
8.2 Conclusions	8-4
8.2.1 Groundwater Movement	8-4
8.2.2 SoPC Migration from OU1 to OU2	8-5
9.0 References	9-1

Volume 2

Appendix A Revised Field Sampling Plan

Appendix B Data Tables

 B1 OU1 Data Tables

 B2 OU2 Data Tables

 B3 Compliance Averaging Data Tables

 B4 Ecological Soil Screening Criteria and Sources

Appendix C Soil Sampling Logs

 C1 Soil Sampling Logs (Phase I Investigation)

 C2 Soil Borehole Logs (Phase IA Supplemental Field Investigation)

Appendix D Test Pit Logs

Appendix E Hydrological Water Elevations and Test Analysis

- Appendix F Monitoring Well Water Quality Parameters
 - F1 Monitoring Well Water Quality Parameters for Phase I
 - F2 Monitoring Well Water Quality Parameters for Phase IA
- Appendix G Sediment Logs
- Appendix H Air Sampling Logs
- Appendix I Hazardous Substance Inventory Logs
- Appendix J Meteorological Data

Volume 3

- Appendix K Well Installation Logs
 - K1 NJDEP Well Installation Logs
 - K2 Phase IA Well Installation Logs
- Appendix L Data Tables for Quality Assurance Reviews
- Appendix M Quality Assurance Review Summaries and Laboratory Case Narratives
 - M1 Phase I Quality Assurance Review Summary and Laboratory Case Narrative
 - M2 Phase IA Quality Assurance Review Summaries and Laboratory Case Narratives
 - M3 Supplemental Field Investigation Quality Assurance Review
- Appendix N Cross Sections of Site Stratigraphy
- Appendix O Cut-off Wall Records Information
- Appendix P Ward Reports (1974, 1975)
- Appendix Q Diamond Shamrock/Henkel Soil Data

Volume 4

Background Investigation Technical Memorandum

This report is also provided in its entirety on CD, which can be found at the end of Volume 1.

List of Figures

- Figure 1-1. Site location map
- Figure 1-2. Site layout map
- Figure 2-1a. Monitoring well locations
- Figure 2-1b. Onsite and offsite soil sampling stations
- Figure 2-1c. Air sampling stations
- Figure 2-1d. Surface water, sediment and seep sampling stations
- Figure 2-1e. Test pits and hazardous substance inventory stations
- Figure 2-2. Cut-off wall excavation locations
- Figure 2-3. U.S. Life Warehouse (Jerbil) evaluation soil and air sample locations
- Figure 3-1. Tidal study hydrographs
- Figure 3-2. 100-year and 500-year floodplain map
- Figure 3-3a. Groundwater surface elevation measurements, time series for each well (MW-1 through MW-8)
- Figure 3-3b. Groundwater surface elevation measurements, time series for each well (MW-9 through MW-15)
- Figure 3-3c. Groundwater surface elevation measurements, variations at each well
- Figure 3-4a. Groundwater elevations December 9, 1997
- Figure 3-4b. Groundwater elevations December 10, 1999
- Figure 3-4c. Groundwater elevations April 10, 2000
- Figure 3-4d. Groundwater elevations September 24, 2002
- Figure 3-5. Approximate distributions of canopy species at the Ventron/Velsicol Site, May 1998

- Figure 3-6. Approximate distribution of understory species at the Ventron/Velsicol Site, May 1998
- Figure 3-7. Approximate distribution of *Phragmites australis* at the Ventron/Velsicol Site, May 1998
- Figure 4-1. Mercury concentrations (mg/kg) in surface soils and sediments (color coding based on screening criteria values)
- Figure 4-2. Methylmercury concentrations (mg/kg and as a percentage of total mercury) in surface soils and sediments
- Figure 4-3. Arsenic concentrations (mg/kg) in surface and subsurface soils and sediments (color coding based on screening criteria values)
- Figure 4-4. Copper concentrations (mg/kg) in surface and subsurface soils and sediments (color coding based on screening criteria values)
- Figure 4-5. Lead concentrations (mg/kg) in surface and subsurface soils and sediments (color coding based on screening criteria values)
- Figure 4-6. Thallium concentrations (mg/kg) in surface and subsurface soils and sediments (color coding based on screening criteria values)
- Figure 4-7. Zinc concentrations (mg/kg) in surface and subsurface soils and sediments (color coding based on screening criteria values)
- Figure 4-8. Benzo[a]pyrene concentrations ($\mu\text{g/kg}$) in surface and subsurface soils and sediments (color coding based on screening criteria values)
- Figure 4-9. Mercury concentrations (mg/kg) in soils from test pits and boreholes (color coding based on screening criteria values)
- Figure 4-10. Cadmium concentrations (mg/kg) in surface and subsurface soils and sediments (color coding based on screening criteria values)
- Figure 4-11. Nickel concentrations (mg/kg) in surface and subsurface soils and sediments (color coding based on screening criteria values)
- Figure 4-12. PAH concentrations ($\mu\text{g/kg}$) in offsite soils (color coding based on screening criteria values)
- Figure 4-13. Mercury concentrations ($\mu\text{g/L}$) in surface water, seeps, and groundwater
- Figure 4-14. Methylmercury concentrations ($\mu\text{g/L}$ and as percentage of total mercury) in surface water, seeps, and groundwater

- Figure 4-15. Arsenic concentrations ($\mu\text{g/L}$) in groundwater (color coding based on screening criteria values)
- Figure 4-16. Cadmium concentrations ($\mu\text{g/L}$) in groundwater (color coding based on screening criteria values)
- Figure 4-17. Iron concentrations ($\mu\text{g/L}$) in groundwater (color coding based on screening criteria values)
- Figure 4-18. Lead concentrations ($\mu\text{g/L}$) in groundwater (color coding based on screening criteria values)
- Figure 4-19. Manganese concentrations ($\mu\text{g/L}$) in groundwater (color coding based on screening criteria values)
- Figure 4-20. Nickel concentrations ($\mu\text{g/L}$) in groundwater (color coding based on screening criteria values)
- Figure 4-21. Selenium concentrations ($\mu\text{g/L}$) in groundwater (no screening criteria available)
- Figure 4-22. Sodium concentrations ($\mu\text{g/L}$) in groundwater (color coding based on screening criteria values)
- Figure 4-23. Thallium concentrations ($\mu\text{g/L}$) in groundwater (color coding based on screening criteria values)
- Figure 4-24. Benzene concentrations ($\mu\text{g/L}$) in groundwater (color coding based on screening criteria values)
- Figure 4-25. Chlorobenzene concentrations ($\mu\text{g/L}$) in groundwater (color coding based on screening criteria values)
- Figure 4-26. Toluene concentrations ($\mu\text{g/L}$) in groundwater (color coding based on screening criteria values)
- Figure 4-27. Xylene isomer concentrations ($\mu\text{g/L}$) in groundwater (color coding based on screening criteria values)
- Figure 4-28. Bis[2-ethylhexyl]phthalate concentrations ($\mu\text{g/L}$) in groundwater (color coding based on screening criteria values)
- Figure 4-29. 1,2-Dichloroethene isomers (total) concentrations ($\mu\text{g/L}$) in groundwater (color coding based on screening criteria values)
- Figure 4-30. 1,1,2,2-Tetrachloroethane concentrations ($\mu\text{g/L}$) in groundwater (color coding based on screening criteria values)

- Figure 4-31. Chromium concentrations (mg/kg) in surface and subsurface soils and sediments (color coding based on screening criteria values)
- Figure 4-32. Silver concentrations (mg/kg) in surface and subsurface soils and sediments (color coding based on screening criteria values)
- Figure 4-33. Particulate and gaseous mercury concentrations (ng/m³) in air
- Plate 1. Topography of the Ventron/Velsicol Site (in pocket)

Figures and plate are presented at the end of the main text.

List of Tables

Table 1-1.	List of SoPCs by media and operable unit
Table 2-1.	Summary of chemical analyses for Phase I samples
Table 2-2.	Summary of chemical analyses for Phase IA samples
Table 3-1.	Summary of groundwater elevation measurements
Table 3-2.	Rising-head slug test results
Table 3-3.	Plant species observed at the Ventron/Velsicol Site
Table 3-4.	Wildlife species observed at the Ventron/Velsicol Site
Table 3-5.	Feeding habits of birds observed at the Ventron/Velsicol Site
Table 3-6.	Feeding habits of mammals observed at the Ventron/Velsicol Site
Table 3-7.	Wetland functional assessment attributes for Ventron/Velsicol Site, best professional judgment method
Table 4-1a.	Summary of SoPCs in onsite surface soil (OU1)
Table 4-1b.	Summary of SoPCs in onsite surface soil (OU1) – developed area only
Table 4-1c.	Summary of SoPCs in onsite surface soil (OU1) – undeveloped area only
Table 4-2a.	Summary of SoPCs in subsurface soil (OU1, test pits and boreholes)
Table 4-2b.	Summary of SoPCs in subsurface soil (OU1, test pits)
Table 4-2c.	Summary of SoPCs in subsurface soil (OU1, boreholes)
Table 4-3a.	Summary of SoPCs in offsite surface soil
Table 4-3b.	Summary of SoPCs in offsite surface soil – locations adjacent to Site
Table 4-3c.	Summary of SoPCs in offsite surface soil – locations not adjacent to Site
Table 4-3d.	Summary of SoPCs in offsite soil boreholes
Table 4-4a.	Summary of SoPCs in groundwater (OU1) – Phase I investigation

Table 4-4b.	Summary of SoPCs in groundwater (OU1) – Phase IA investigation
Table 4-4c.	Summary of SoPCs in groundwater (OU1) – Supplemental Phase IA investigation
Table 4-4d.	Summary of SoPCs in groundwater – Phase IA SFI
Table 4-5a.	Summary of SoPCs in seeps (OU1) – Phase I
Table 4-5b.	Summary of SoPCs in seeps (OU1) – Phase IA
Table 4-6a.	Summary of SoPCs in surface water (OU1) – onsite basin only
Table 4-6b.	Summary of SoPCs in surface water (OU1) – West Ditch only
Table 4-6c.	Summary of SoPCs in surface water (OU2)
Table 4-7a.	Summary of SoPCs in sediment (OU1) – onsite basin only
Table 4-7b.	Summary of SoPCs in surface water (OU1) – West Ditch only
Table 4-7c.	Summary of SoPCs in streambed sediment (OU2)
Table 4-7d.	Summary of SoPCs in marsh soils/sediment (OU2)
Table 5-1a.	Summary of groundwater conventional analytes and field parameters for Phase I sampling
Table 5-1b.	Summary of groundwater conventional analytes and field parameters for Phase IA sampling
Table 5-1c.	Summary of groundwater conventional analytes and field parameters for supplemental Phase IA sampling
Table 5-2.	Characteristic values of landfill leachate in groundwater
Table 5-3.	Reported background concentrations of metals and SVOCs in soils

Tables are presented at the end of the main text.

Acronyms and Abbreviations

AA	Assessment Area
ACOE	Army Corps of Engineers
ADA	Aquatic Diversity and Abundance Effectiveness
BBL	Blasland Bouck & Lee
Berk	F.W. Berk and Company, Inc.
BITM	<i>Background Investigation Technical Memorandum</i>
bgs	below ground surface
BPJ	best professional judgment
DEHP	bis[2-ethylhexyl]phthalate
DEIS	Draft Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
FA	Flood flow Alteration Effectiveness
FAO	Flood flow Alteration Opportunity
FG3	General Fish Habitat Effectiveness
FSP	field sampling plan
FW2	freshwater class 2
GWD	Groundwater Discharge Effectiveness
GWF	General Waterfowl Habitat Effectiveness
GWL	General Wildlife Habitat Effectiveness
GWQS	Groundwater Quality Standards
GWR	Groundwater Recharge Effectiveness
HMC	Hackensack Meadowlands Commission
HMD	Hackensack Meadowlands District
HMDC	Hackensack Meadowlands Development Commission
IDL	instrument detection limit
IGWSCC	Impact to Groundwater Soil Cleanup Criteria
IVA	Indicator Value Assessment
JD	jurisdictional determination
Lpm	liters per minute
Morton	Morton International, Inc.
msl	mean sea level
NAPL	nonaqueous phase liquids
NIOSH	National Institute of Occupational Safety and Health
NJDEP	New Jersey Department of Environmental Protection
NR	Nutrient Removal/Transformation Effectiveness
NRDCSCC	Non-Residential Direct Contact Soil Cleanup Criteria (New Jersey)
NRO	Nutrient Removal/Transformation Opportunity
OU1	Operable Unit 1
OU2	Operable Unit 2
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PE	Production Export Effectiveness
PID	photoionization detector

Plant	processing plant
POTW	publicly owned treatment works
RDCSCC	Residential Direct Contact Soil Cleanup Criteria (New Jersey)
Resolution	Resolution of the Berry's Creek/Wood-Ridge Site Action Committee
RI/FS	remedial investigation/feasibility study
Site	Ventron/Velsicol Site
SoPCs	substances of potential concern
SS	Sediment Stabilization Effectiveness
Stipulation	Stipulation and Supplementary Order Approving Cooperative Agreement for Remedial Investigation and Feasibility Study and Amending Procedural Order Involving Remedy
STR	Sediment/Toxicant Retention Effectiveness
STRO	Sediment/Toxicant Retention Opportunity
SVOC	semivolatile organic compound
SWQS	Surface Water Quality Standards
TAL	target analyte list
TCL	target compound list
TSS	total suspended solids
Velsicol	Velsicol Chemical Corporation
Ventron	Ventron Corporation
VOC	volatile organic compound
Wolf	Robert & Rita Wolf
WRCC	Wood Ridge Chemical Corporation
WET	Wetland Evaluation Technique
Work Plan	<i>Remedial Investigation/Feasibility Study Work Plan</i>

1.0 Introduction

On behalf of Morton International, Inc. (Morton) and Velsicol Chemical Corporation (Velsicol), Exponent is conducting a remedial investigation and feasibility study (RI/FS) for the Ventron/Velsicol Site, located in Wood-Ridge and Carlstadt, New Jersey. Morton is now a wholly owned subsidiary of Rohm and Haas Company. Velsicol has petitioned the Superior Court of New Jersey to substitute LePetomane III, Inc. Custodial Trust in the Consent Order and stipulation discussed below.

The RI/FS is required by the “Resolution of the Berry’s Creek/Wood-Ridge Site Action Committee” (Resolution) with the New Jersey Department of Environmental Protection (NJDEP), executed on August 15, 1996. The Resolution is an amendment to the October 26, 1984, *Stipulation and Supplementary Order Approving Cooperative Agreement for Remedial Investigation and Feasibility Study and Amending Procedural Order Involving Remedy* (Stipulation). The Stipulation covers the approximately 38-acre Ventron/Velsicol Site and the areas of Berry’s Creek potentially affected by industrial activity at the Site, while the Resolution provides for implementation of a separate RI/FS for the Ventron/Velsicol Site. The Ventron/Velsicol Site is designated as a National Priorities List site identified by the U.S. Environmental Protection Agency (EPA) number NJD980529879, and bearing CERCLIS ID number 02C7.

This document presents the results of a remedial investigation for the Ventron/Velsicol Site (referred to in this report as the “Site”). This document was prepared in accordance with the reporting approach shown in Figure 5-2 of the *Remedial Investigation/Feasibility Study Work Plan* (Phase I Work Plan) (CRA 1996). As shown in that figure, risk assessment and feasibility study reports will be prepared and presented in separate documents.

The purpose of this remedial investigation report is to present the Phases I and IA site characterization methods and results and to identify additional data, if any, needed to support the remedial investigation objectives. This report is structured in accordance with the EPA guidance for reporting on site investigations under the Comprehensive Environmental Response, Compensation and Liability Act (U.S. EPA 1988a) and also addresses the requirements of the NJDEP Technical Requirements for Site Remediation (NJAC 7:26E). Section 1 provides a general site description, a site history, and a summary of the substances of potential concern (SoPCs) for the Site. The remainder of this report consists of eight sections and three volumes of supporting attachments, as follows:

- *Field and Laboratory Investigations* (Section 2) describes the investigations performed as part of this remedial investigation
- *Physical Characteristics of the Site* (Section 3) provides an overview of the Site's physical characteristics based on both data collected as part of this remedial investigation and data from other sources
- *Nature and Extent of Contamination* (Section 4) describes the measured distribution of SoPCs for the Site
- *Transport and Fate of SoPCs* (Section 5) describes the transport and fate of SoPCs at the Site
- *Human Health Risk Assessment* (Section 6) will be provided as a separate document
- *Ecological Risk Assessment* (Section 7) will be provided as a separate document
- *Summary and Conclusions* (Section 8) summarizes key results from this remedial investigation
- *References* (Section 9) provides a list of references cited in this document
- *Appendices A through J* in Volume 2
- *Appendices K through Q* in Volume 3
- The *Background Investigation Technical Memorandum* (BITM) in Volume 4.

1.1 Purpose and Organization

The overall purpose of this remedial investigation is to develop sufficient site characterization information to support informed risk management decisions for the Site. The risk management decisions will be supported by the subsequent risk assessment and feasibility studies to be prepared as part of the RI/FS process.

The specific objectives of the Phase I remedial investigation were to:

- Identify SoPCs that have been released from and are present at or adjacent to the Site
- Identify and characterize the sources of SoPCs at the Site

- Characterize the spatial distribution of SoPCs at the Site
- Characterize the transport and fate in the environment of SoPCs at the Site.

The major Phase I remedial investigation activities conducted to support achievement of these objectives included:

- Sampling and analysis of environmental media at the Site
- Geophysical and hydrogeological investigations
- Wetlands assessment
- Cultural resources survey
- Hazardous substance inventory.

These investigations were performed in accordance with the Phase I Work Plan (CRA 1996) approved by NJDEP on March 19, 1996. Some modifications to this plan were approved by NJDEP prior to performing the field work and are documented in the revised version of the field sampling plan (FSP) provided in Appendix A. Other modifications were needed based on the field conditions encountered. These modifications are described in Section 2.

A Phase IA remedial investigation and supplemental field investigation (SFI) were subsequently performed to collect additional data. Additional data needs were identified in Section 8.3 of the December 1998 Agency Review Draft Phase I remedial investigation report and in Agency comments presented in NJDEP's April 1, 1999 and November 1, 2001 letters. The need for data from the West Ditch and a second round of seep samples was also identified. Results of the Phase IA remedial investigation and the West Ditch and seep sampling were included in the 2000 Operable Unit 1 (OU1) remedial investigation report (Exponent 2000a) and results of the Phase IA SFI were initially submitted as the OU1 Phase IA supplemental field investigation data report (Exponent 2003). The findings of the Phase IA SFI, along with changes based on review comments, have been incorporated into this remedial investigation report. Therefore, this remedial investigation report supersedes both previous reports (Exponent 2000a, 2003).

The principal objectives of the Phase IA remedial investigation and SFI were to:

- Complete the offsite delineation of mercury in surface and subsurface soils
- Refine the characterization of SoPCs in groundwater
- Refine the delineation of groundwater flow in the vicinity of the transition from the developed area to the undeveloped filled area

- Evaluate the potential for seasonal changes in groundwater surface elevations
- Refine the characterization of SoPCs in seeps
- Characterize sediment and surface water quality in the West Ditch
- Find documentation or evidence of a cutoff/containment wall near the northwest perimeter of the undeveloped filled area of the Site.

The major Phase IA remedial investigation and SFI activities conducted to support achievement of these objectives included:

- Collect surface soil samples from four offsite locations along the northwestern Site boundary
- Install three additional groundwater monitoring wells
- Collect subsurface soil samples from the three new monitoring well boreholes
- Perform soil boring at eight onsite locations and collect soil samples (if elemental mercury was observed or mercury vapor was detected in the field)
- Collect soil samples from six offsite soil boreholes along the northwest property boundary adjacent to Ethel Boulevard
- Collect groundwater samples from twelve existing and three newly installed monitoring wells then analyze these samples for organic compounds and selected metals using more sensitive techniques than were used during the Phase I remedial investigation
- Perform groundwater elevation measurements at twelve existing and three new monitoring wells approximately every 2 months for approximately 6 months
- Collect seep samples from approximately the same five locations sampled during the Phase I remedial investigation
- Collect three surface water and three sediment samples from the West Ditch
- Conduct a records search for information on the construction of a cutoff/containment wall.
- Conduct a subsurface investigation to confirm the existence and location of the cutoff/containment wall.

These investigations were performed in accordance with approved work plans (Exponent 1999, 2002). Some modifications to these plans were necessary and are described in Section 2.

The objectives of the Phases I and IA remedial investigations were met through evaluation of information obtained during these remedial investigations (from the activities described above) combined with results obtained by NJDEP in 1990–1991 during air, groundwater, and soil studies performed by NJDEP. SoPCs were identified through chemical analyses of environmental media from and adjacent to the Site and subsequent screening of the chemical analysis results against relevant regulatory and ecological screening criteria. The Phases I and IA chemical analyses, together with information derived from the hazardous substance inventory and the geophysical investigation, provide a sufficient understanding of the sources and distribution of SoPCs on Site to meet the remedial investigation objectives. The transport and fate in the environment of SoPCs were characterized based on the observed concentrations in the various media, geochemical conditions at the Site, the potential mobility of SoPCs, and potential interactions among the various environmental media. Further evaluation of transport and fate may be needed to support subsequent activities such as the risk assessment or feasibility study.

In addition to the Phases I and IA remedial investigations, air and surface soil samples were collected during the spring of 1999 from a vacant space inside the U.S. Life (Jerbil) warehouse while the warehouse was undergoing renovations. Surface soil samples were also collected from an area in the parking lot where additional building construction was planned. The objectives of this warehouse renovation study were to assess the potential inhalation exposure to construction workers, characterize the fill inside the warehouse prior to disposal, and to sample additional soil from beneath the asphalt parking lot. Data from this warehouse renovation study are incorporated in this report.

Previous investigations at the Site, other than the NJDEP studies in 1990–1991, were used to provide general background knowledge of Site conditions but were not incorporated into the data set used to meet the remedial investigation objectives. This is because data from these prior investigations is of unknown quality. Exponent was not able to find information to support assessment of the data quality from these prior investigations and has not, therefore, attempted to validate or assess the quality of that data, some of which may not be of suitable quality to combine directly with data collected for the remedial investigation. An overview of these previous investigations is presented in the BITM (Volume 4 of this remedial investigation report).

1.2 Site Description

The Site is located in Bergen County, New Jersey, within the boroughs of Wood-Ridge and Carlstadt. It is an irregularly shaped, approximately 38-acre area within an industrialized area of northeastern New Jersey. Approximately 15.7 of the 38 acres are within the Borough of Wood-Ridge, and the remaining 22.6 acres are within the Borough

of Carlstadt. The entire Site is generally within the Hackensack Meadowlands area, and the portion in Carlstadt is within the jurisdiction of the New Jersey Meadowlands Commission (known as the Hackensack Meadowlands Development Commission [HMDC] prior to 2001). Figure 1-1 shows the Site location.

The Site is bordered to the east by Berry's Creek, to the west by the Diamond Shamrock/Henkel and Randolph Products properties and Park Place East, to the south by Diamond Shamrock/Henkel Ditch (south) and Nevertouch Creek, and to the north by Ethel Boulevard and a railroad track. Two active commercial/industrial facilities and an empty lot, on which a publicly owned treatment works (POTW) was formerly located, lie immediately north of Ethel Boulevard and the railroad track. The railroad crosses Berry's Creek at the northeast corner of the Site and continues south along the eastern side of Berry's Creek.

Land use in the immediate vicinity of the Site is primarily commercial/industrial. Teterboro Airport is located approximately 0.6 miles to the north, State Highway 17 is approximately 500 ft to the west, and the Meadowlands Sports complex is approximately 1 mile to the south. The immediately adjacent Diamond Shamrock/Henkel property is undergoing an active remediation program under the NJDEP Environmental Cleanup Responsibility Act. The closest residential area is approximately 750 ft to the north.

Two active warehouses, referred to as the Wolf Warehouse and the U.S. Life Warehouse, are located on the northernmost portion of the Site. The Wolf Warehouse is east of the U.S. Life Warehouse. The former mercury processing facility was located on the portion of the Site that is now occupied by these warehouses. This portion of the Site covers approximately 7 acres and will be referred to as the "developed" portion of the Site.

Approximately 19 acres of land that were filled but not developed lie generally south of the developed portion of the Site. This portion of the Site is bordered to the north by the railroad track, to the south by the Diamond Shamrock/Henkel Ditch (north), and to the east by Berry's Creek. This area will be referred to as the "undeveloped filled" portion of the Site.

The remaining 12 acres of the Site, south of the undeveloped filled area, do not appear to have been filled and are generally marsh, except for a fringe of fill along the western border. There is no development within this portion of the Site, which will be referred to as the "marsh" portion of the Site.

Figure 1-2 shows the Site layout, indicating the three portions of the Site described above. In accordance with instructions in an April 1, 1999, letter from the NJDEP, the Site has been divided into two operable units. OU1 consists of both the developed and undeveloped, filled portions of the Site, as described above. Operable Unit 2 (OU2) consists of the marsh portion of the Site and all the adjacent water bodies, including Berry's Creek, Nevertouch Creek, and the Diamond Shamrock/Henkel Ditches. The drainage ditches on the developed area, the onsite basin, and the West Ditch are considered part of OU1.

1.3 Site History

Prior to 1927, most of the Site was marshland. From 1927 to 1974, various parties constructed and operated a mercury processing plant on the developed portion of the Site. In 1929, F.W. Berk and Company, Inc. (Berk) began operating a processing plant (Plant) and manufacturing mercury products near the current location of the Wolf Warehouse. Berk initially leased the land from the Carlstadt Development and Trading Company, but purchased the land in 1943. Between 1952 and 1955, the Magnesium Elektron Corporation (a New Jersey corporation, formerly Melberk, Inc.) leased a portion of the property that included a structure known as the Zirconium Building. Berk continued to operate the Plant until 1960, when the corporation dissolved and the Plant and property were sold to the Wood Ridge Chemical Corporation (WRCC), a wholly owned subsidiary of the Velsicol Chemical Corporation (Velsicol).

The main operations of the mercury processing plant included the manufacture of red oxide of mercury, yellow oxide of mercury, phenyl mercuric acetate, and other organic and inorganic mercury compounds. The plant also reclaimed mercury from both in-house and customer waste products (amalgams, batteries, thermometers, impure mercury, etc.). The operations at this processing facility appear to be generally similar throughout its manufacturing history (ERM 1985).

Velsicol continued to operate the Plant until 1968, when the Ventron Corporation (Ventron), a predecessor to Morton, purchased WRCC and the approximately 7-acre parcel on which the Plant was located from Velsicol. Velsicol retained ownership of the rest of the Site property until transferring ownership to NWI Land Management, Inc., in 1986. Ventron operated the Plant until it was closed in 1974. In 1974, the parcel of land where the Plant was located was sold to Robert and Rita Wolf (Wolf). Wolf demolished the Plant in 1974, and in 1975, subdivided the land and transferred title of the westernmost parcel to U.S. Life Insurance Company. Two warehouses were constructed, one on each parcel.

The former mercury processing facility location extended to the north beyond the location of the existing warehouses, near the north property boundary (northeast of the existing Wolf Warehouse). Prior to the installation in 1961 of the railroad tracks that now border Ethel Boulevard on the north side of the Site, it is possible that contaminated soils or wastes could have been placed in this area. The presence of mercury above the Residential Direct Contact Soil Cleanup Criteria (RDCSCC) in subsurface intervals likely resulted from regrading prior to construction of the Berger warehouse or vertical migration from surface soils. While localized groundwater flow toward the northeast cannot be ruled out, the most likely source of mercury to offsite soils near the northern boundary of the Site is historical plant operations.

Some information is available on activities that occurred during the closing of the mercury processing operations and construction of the warehouses. According to

information provided in Appendix O, the warehouse on the western portion of the Site (U.S. Life [Jerbil] Warehouse) was built first, after removal of the upper layer of contaminated soil to the eastern portion of the Site. Representatives of Wolf, NJDEP, and EPA agreed to this approach in August of 1974. It is likely that some clean fill was applied to the soil surface before construction of the U.S. Life (Jerbil) Warehouse, although the horizontal and vertical extent of the fill is unknown.

Construction of the Wolf Warehouse occurred with oversight by NJDEP and EPA based on an “entombment” or “encapsulation” plan as described in Appendix O. The entombment plan entailed construction of a continuous perimeter footing in contact with the organic layer of soil (considered by the consulting geotechnical engineer at the time [Joseph S. Ward, Inc.] to be impervious), construction of a shallow containment wall around the perimeter of the eastern and southern property lines, complete impervious paving of the surface, and construction of water-impervious ditches for drainage from the Site. Soils containing elevated mercury concentrations were acknowledged to remain in place beneath the warehouse, with the combination of paving, containment wall, and warehouse flooring serving to encapsulate these soils. The location and extent of the containment wall was assessed during the Phase IA investigation as described in Section 2.11. The containment wall was found in only two of five locations tested. Therefore, the wall, if present, is discontinuous.

Lipsky et al. (circa 1980) reported that subsequent to 1960, the approximately 19-acre portion of the Site between the developed area and Berry’s Creek was used as a dumping area for various material including demolition material and domestic solid waste. The record of property easements confirms use of the Site for municipal waste dumping by the Borough of Wood-Ridge (see Attachment A, Easements/Rights of Way Item 5).

Information in the easements for properties on the Site (see BITM Attachment A, Easement/Rights of Way Items 3 and 5) suggests that two drainage pipes may have been installed on the undeveloped filled portion of the Site between the developed portion and Berry’s Creek. According to the easements, one of these pipes was related to the Borough of Wood-Ridge waste disposal activities and the other was related to conveyance of WRCC effluent across property then owned by Velsicol. However, the exact location of these pipes is uncertain. Figures B-1, B-2, and B-4 in BITM Attachment B and a figure in Item 5 of BITM Attachment A, Easement/Rights of Way, show various postulated locations for drainage pipes. The source, date, and origin of the information contained in BITM Figure B-1, provided to Exponent by NJDEP, are unknown.

At present, three parties own property on the Site. Jerbil Incorporated owns the U.S. Life Warehouse property (approximately 4.2 acres), Jonathan and Roni Blonde own the Wolf Warehouse property (approximately 2.3 acres), and the LePetomane III, Inc. Custodial Trust owns the undeveloped filled (approximately 19 acres) and marsh (approximately 12 acres) areas. The LePetomane III, Inc. Custodial Trust is the successor to NWI Land Management, Inc. following the discharge in bankruptcy of NWI’s parent, Fruit of the Loom, Inc.

In 1990, NJDEP performed a removal action for soils in residential areas of Wood-Ridge and Moonachie near the Site. Information about this removal action presented here is taken from a report on an NJDEP briefing for local officials. The removal actions were conducted at ten properties in Wood-Ridge and one property in Moonachie. The work included excavation of mercury-contaminated soil, placement of clean back-fill, revegetation, and general restoration of the properties to their original condition. The remedial action criterion was 14 parts per million (ppm, or $\mu\text{g/kg}$) of mercury in soil. During this removal action, approximately 800 samples were collected. The remedial criterion of 14 ppm was set by NJDEP at the time.

1.4 Substances of Potential Concern

SoPCs are those substances that merit evaluation of their nature and extent (Section 4) and potential fate and transport (Section 5). SOPC selection is based on comparing concentrations in site media to relevant or appropriate criteria values. This section describes the initial list of SoPCs for this Site and the process used to develop this list. The list may be further refined through the course of assessing risks associated with the Site.

Mercury is the substance most clearly associated with the Plant. Other inorganic substances that may be associated with Plant activities include cadmium, chromium, copper, iron, lead, silver, thallium, and zinc. These inorganic substances were used at the Plant and were also measured at concentrations greater than the relevant screening criteria in at least one of the environmental media sampled at the Site. These and other SoPCs may also have been contributed by sources other than industrial operations at the Site.

Samples collected from Site media were analyzed for a wide range of substances, as specified in Phases I and IA Work Plans (CRA 1996; Exponent 1999). In this SoPC identification process, 46 substances were identified based on comparisons with the screening criteria values from the sources listed below. The specific screening criteria values used in this SoPC selection process are listed in the media-specific data tables included in Appendix B.

- Soil Cleanup Criteria (Revised 5/12/99)–Non-Residential and Residential Direct Contact Soil Cleanup Criteria (Cleanup Standards for Contaminated Sites, N.J.A.C. 7:26) (NRDCSCC and RDCSCC, respectively)
- Soil Cleanup Criteria (Last Revised 5/12/99)–Impact to Groundwater Soil Cleanup Criteria (Cleanup Standards for Contaminated Sites, N.J.A.C. 7:26) (IGWSCC)

- EPA soil screening guidance (U.S. EPA 1996): soil screening levels (SSLs) for migration to groundwater (for metals only)
- Ecological screening criteria for soils (the most conservative screening criteria were selected based on a review of NJDEP-recommended sources of screening values; Appendix B contains the full citation for each of the sources used)
- Specific groundwater quality criteria (Ground Water Quality Standards [N.J.A.C. 7:9-6]) (GWQS)
- Surface Water Quality Standards (SWQS)—criteria for FW2 (freshwater class 2) N.J.A.C. 7:9B
- EPA drinking water standard maximum contaminant levels (MCLs)
- NJDEP *Guidance for Sediment Quality Evaluations* for freshwater sediments (NJDEP November 1998): Lowest Effects Level and Chronic Values.

Table 1-1 lists the Site SoPCs by environmental medium and by operating unit. The Site SoPCs include 20 metals, 6 volatile organic compounds (VOCs), 18 semivolatile organic compounds (SVOCs), and 2 polychlorinated biphenyl (PCB) Aroclor[®] mixtures. Sections 4 and 5 of this report focus on these SoPCs. Complete chemical analysis results, with highlighting of individual values that exceed the relevant criteria, are provided in Appendix B.

The selection of SoPCs specific to each medium is discussed in the following narrative. While the SoPC selection process was medium specific, the potential for interactions among media, where relevant, is addressed in Section 5.

In some cases, concentrations were reported as not detected, but with detection limits above the relevant criteria value. If there were no criteria exceedances for detected concentrations, such substances were not identified as SoPCs.

SoPCs for OU1 soils were selected using a two-step process. First, the individual sample concentrations were compared to the relevant criteria values (NRDCSCC, RDCSCC, or IGWSCC, as appropriate) or EPA SSLs (for metals only). Substances for which there were one or more exceedances were then evaluated using the averaging provisions in N.J.A.C. 7:26E, (Technical Requirements for Site Remediation) and a Spring 1995 article issued by NJDEP entitled “Compliance Averaging” (NJDEP 1995, see Appendix B3). The guidelines established for compliance averaging allow criteria exceedances to be determined by comparing the arithmetic mean of all sample concentrations in a contaminated area to the relevant criteria value, but also establish the maximum allowable concentrations for individual substances. Compliance averaging is applicable to SoPC selection for surface soils and subsurface soils. Appendix B3 Tables B3-1

through B3-3 present the results of compliance averaging for OU1 surface and subsurface soils.

Surface soil SoPCs in OU1 were selected based on comparing concentrations to the NRDCSCC and using the averaging provisions described above (See Appendix B3, Table B3-1). Surface soils were additionally screened against ecological screening criteria (as described above and in Appendix B4, Table B4-1). Subsurface soil SoPCs in OU1 were selected based on comparing concentrations to NRDCSCC, IGWSCC, and EPA SSLs (for metals only) and using the averaging provisions described above (See Appendix B3, Table B3-2). Subsurface soil concentrations in samples collected as part of the test pit excavations and in samples collected during the Phase IA well installations were used to compute the Site arithmetic mean values. Data from the NJDEP investigation (NJDEP 1993a) were not used to compute average values because the data set is not complete and does not, therefore, support computation of averages. Screening of the available individual values from the NJDEP investigation does not add any SoPCs to those identified using the Phases I and IA remedial investigation data. The NRDCSCC are not directly relevant to subsurface soils, because there is negligible potential for direct contact with these soils. Nevertheless, as a conservative approach, the NRDCSCC were applied in this screening evaluation. Note that there are no IGWSCC for inorganic substances and the NRDCSCC are generally much lower than the IGWSCC for SVOCs.

Measured concentrations in groundwater samples collected from the 15 monitoring wells located throughout the developed and undeveloped filled portions of the Site were compared to GWQS and MCLs. Concentrations in the 8 wells adjacent to surface water (MW-1, MW-3, MW-4, MW-5, MW-6, MW-8, MW-12, MW-15) were also compared to SWQS. Sodium levels in groundwater samples also exceeded the criterion at most wells. Sodium is not associated with known or suspected releases at the Site and is most likely related to natural causes. Nevertheless, it was retained as an SOPC in this report since the concentrations exceeded criteria values. The results available from filtered groundwater samples collected during the NJDEP investigation in 1991 (NJDEP 1993a) were also screened against the GWQS and MCLs. Screening of the filtered values from the NJDEP investigation against the MCLs adds antimony to the SoPCs identified using the Phase I and IA remedial investigation data.

Filtered seep samples collected from the banks of the Diamond Shamrock/Henkel Ditch (north) and Berry's Creek were screened against the GWQS and SWQS. As mentioned above for groundwater, the sodium concentrations in seeps are likely to be related to natural sources, but it was retained as an SOPC because of criteria exceedances.

Sediment samples were collected from two locations within OU1: the onsite basin and the West Ditch. Sediment samples were also collected from three locations within OU2: the Diamond Shamrock/Henkel Ditch (north), Berry's Creek, and the marsh portion of the Site. Measured concentrations in these samples were screened against the freshwater sediment screening criteria.

Unfiltered and filtered surface water samples were screened against SWQS criteria. Several of the SWQS values for metals are hardness dependent. Hardness measurements were not performed during the Phase I investigation, presumably because the Phase I work plan assumed surface water in the vicinity of the Site was saline. In the course of the Phase I investigation, salinity measurements made over the entire tidal cycle varied between one to two parts per thousand, thus surface waters were classified as freshwater. In the absence of hardness values for the surface water samples, the standard assumption of 100 mg/L was used as the total hardness concentration.

Offsite surface soil SoPCs near OU1 were selected based on comparing concentrations to the Residential Direct Contact Soil Cleanup Criteria (RDCSCC) and using the averaging provisions described above (See Appendix B3, Table B3-3). Additionally, offsite soil was screened using the ecological screening criteria. A total of 22 offsite surface soil samples were collected and analyzed for a site-specific offsite soils chemical indicator list. This list was developed by comparing the onsite surface soil analytical results with the RDCSCC. Additionally, four samples collected along the Norfolk Southern railroad spur during Phase IA and samples from six borehole locations along the northern property boundary during the Phase IA SFI were analyzed for mercury only. The RDCSCC were used only for the purposes of delineating the nature and extent of the contamination at these offsite locations, and for selecting the offsite SoPCs. Since these substances are not necessarily Site SoPCs, they are not listed in Table 1-1. Offsite soil SoPCs are discussed further in Sections 4 and 5. Four metals (copper, lead, mercury, and zinc) and six SVOCs (benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, dibenz[a,h]anthracene, and indeno[1,2,3-cd]pyrene) had measured concentrations at offsite locations that exceeded the RDCSCC and were retained as offsite SoPCs after applying the averaging provisions. With one exception (mercury at depth in one borehole from 2002), all substances measured in offsite soils for which there was a reasonable likelihood of a relationship to the Site were delineated to below the RDCSCC criteria values.

2.0 Field and Laboratory Investigations

The Site investigation activities that generated data for the remedial investigation included the Phase I remedial investigation field investigation (Fall of 1997 through Spring of 1998), the Phase IA field investigation (Fall of 1999 through Spring of 2000), the NJDEP investigation (1990 and 1991) (NJDEP 1993a), the supplemental study related to renovations at the U.S. Life Warehouse (April 1999), and the Phase IA SFI (Fall of 2002).

The Phase I remedial investigation field investigation consisted of ten components:

- Onsite and offsite surface soils investigation
- Subsurface soils investigation
- Hydrogeological investigation
- Leachate/seep sampling
- Surface water and sediment investigation
- Wetlands investigation
- Air sampling
- Hazardous substance inventory
- Topographic and location survey
- Cultural resources investigation.

The Phase I remedial investigation field sampling program was intended to characterize the current Site conditions, and to identify and evaluate SoPCs in the various media of concern and was performed in accordance with the approved Phase I Work Plan (CRA 1996), as amended.

The Phase IA field investigation consisted of six components:

- Offsite surface soils investigation
- Groundwater well installation and borehole soils investigation
- Hydrogeological investigation
- Leachate/seep sampling

- Surface water and sediment investigation
- Cutoff/containment wall records search and subsurface investigation.

The Phase IA field program was designed to address data needs identified by the Respondents and the Agencies during the preparation and review of the Phase I remedial investigation report (Exponent 1998) and the 2000 OU1 remedial investigation report (Exponent 2000a). The Phase IA investigation was performed in accordance with approved Phase IA work plans (Exponent 1999, 2002).

Field investigation activities were performed by Exponent or by subcontractors working under the direction of Exponent. For the Phase IA remedial investigation, Land N Sea Environmental Services, Inc. conducted Site clearing activities, perimeter fence maintenance, and the test-pit excavations (Section 2.2.2), and the subsurface investigation for the cutoff/containment wall (Section 2.11). James M. Stewart, Inc. (Stewart) provided a range of topographic and location surveying services (Section 2.9). Cultural Resources Consulting Group conducted the cultural resources investigation (Section 2.10). Shisler Environmental Consultants conducted the wetlands investigation (Section 2.6). The hazardous substance inventory (Section 2.8) and the geophysical (Section 2.2.1) and Phase I hydrogeological investigations (Section 2.3) were performed by Blasland, Bouck & Lee, Inc. (BBL). BBL also collected the onsite and offsite surface soil samples (Section 2.1), the subsurface soil samples (Section 2.2.3), the groundwater samples (Section 2.3.3), and the first round of air samples (Section 2.7). Eastern Well Drillers installed three new groundwater wells during the Phase IA field program (Section 2.12). Laboratory analyses for the Phase I samples were conducted by Severn Trent Services (formerly AEN Laboratories), with some additional analyses performed by CEBAM Analytical (methylmercury) and Frontier Geosciences (particulate and gaseous mercury). Laboratory analyses for the Phase IA field investigation were conducted by Columbia Analytical Services, with some additional analyses performed by CEBAM Analytical (mercury and methylmercury) and Severn Trent Services (selected metals). Quality assurance review of the analytical results was performed by QA/QC Solutions.

For the Phase IA SFI in 2002, Summit Drilling advanced soil boreholes. Laboratory analyses were conducted by Columbia Analytical Services and Severn Trent Services, with mercury analyses in groundwater performed by CEBAM Analytical. Exponent performed the quality assurance review of the analytical results.

The NJDEP investigation (NJDEP 1993a) included installation of 12 wells and 3 piezometers nested with wells MW-1, MW-4, and MW-12. Soil samples for chemical analysis were collected from the boreholes and water samples for chemical analysis were collected from the 12 monitoring wells.

A supplemental study related to the warehouse renovations was performed in April 1999 to address concerns by NJDEP about potential mercury vapor exposure to construction workers involved in renovation work at the U.S. Life (Jerbil) warehouse. Although not

part of the RI/FS being conducted at the Site, the approach and results of the study are incorporated in this report to further the understanding of the nature and extent of contamination on the developed area of the Site. This supplemental study was performed in accordance with a letter dated April 15, 1999, from Gwen Zervas of NJDEP to Ken Walanski of Morton.

Before the Phase I field investigation and sample collection began, Site clearing and baseline surveying were performed. Site clearing was performed on September 29 and 30, 1997, removing brush and trees to allow vehicle access to the undeveloped filled area. Access roads began at the Site entrance gate at Ethel Boulevard. One road extended along the southwestern Site boundary adjacent to the Randolph Products and Diamond Shamrock/Henkel properties, ending in a turnaround at the Diamond Shamrock/Henkel Ditch (north). A second access road crossed the undeveloped filled area in a southeasterly direction, ending in a turnaround near Berry's Creek. The brush and trees removed from the access roads were chipped and left on Site. The clearing did not include any soil disturbance or addition of roadbed material to the Site. Additional clearing was performed prior to the Phase IA field investigation to maintain the access roads, provide access to new monitoring well locations, and to link the turnaround at the Diamond Shamrock/Henkel Ditch (north) with the access road to Berry's Creek.

A decontamination pad was constructed near the Site entrance gate. The pad consisted of a polyethylene liner over a bed of sand that provided a uniform surface beneath the liner and protected it from punctures or tears. The sides of the decontamination pad were bermed to prevent runoff of decontamination fluids. For the duration of the Site investigation, all equipment decontamination was conducted in this area. Decontamination fluids collected from cleaning and rinsing of equipment were transferred to a U.S. Department of Transportation–approved steel 55-gal drums. At the completion of the Phase I field activities, a sample from the collected fluid was tested using the analysis methods listed on Table 2-1 and subsequently characterized as non-hazardous material. The collected fluid was released to the ground surface at the Site.

A boundary survey of the Site was conducted in October 1997. In addition, a 100×100-ft control grid was established. Figures 2-1a through 2-1e show the location of this grid. These and additional surveying activities are described in Section 2.9, Topographic and Location Survey.

Standard operating procedures were adhered to in the collection of all samples. These procedures, including the decontamination of all sampling equipment, are outlined in the revised FSP (see Appendix A). The analytical laboratory provided pre-cleaned and appropriately preserved sample containers. All samples were clearly labeled and stored on ice in a cooler until a representative of the analytical laboratory retrieved them at the Site. Samples collected for mercury and methylmercury and atmospheric mercury analysis were shipped to the designated laboratories by overnight delivery service. All samples were maintained under full chain-of-custody procedures at all times. Field procedures and observations were recorded in bound field notebooks.

Sections 2.1 through 2.10 briefly describe the Phase I field and laboratory investigations. More detailed information on procedures can be found in the revised FSP (Appendix A). Section 2.11 and 2.12 summarize the Phase IA field and laboratory investigations that were performed in accordance with the Phase IA Work Plans (Exponent 1999, 2002). Section 2.13 summarizes the supplemental study related to the warehouse renovations.

For each of the field and laboratory investigations, the following subsections describe the objectives for the collection of data, the approach, and deviations from the Phase I and Phase IA Work Plans (CRA 1996; Exponent 1999, 2002). All Phase I and IA sample locations are depicted in Figures 2-1a through 2-1e. Figure 2-2 depicts the cut-off wall excavation locations and Figure 2-3 shows the warehouse evaluation sample locations.

The NJDEP approved several modifications to the original Work Plans and FSP (CRA 1996; Exponent 1999, 2002) before beginning the field programs. The Phase I modifications are summarized below.

- Methylmercury was analyzed in 28, rather than all 52 onsite surface soil samples collected (Section 2.1.1)
- Geophysical anomalies were measured using an electromagnetic induction instrument instead of a magnetometer (Section 2.2.1)
- Methylmercury was analyzed in 7, rather than all 38 subsurface soil samples collected from the test pits (Section 2.2.3)
- A low-flow sampling method was used to collect groundwater samples (Section 2.3.3)
- Two additional surface water and surface sediment (Section 2.5) samples were collected in the onsite basin
- Seep (Section 2.4) and surface water (Section 2.5) samples designated for dissolved target analyte list (TAL) metals analyses were filtered in the laboratory rather than in the field
- Seep (Section 2.4) and filtered and unfiltered surface water (Section 2.5) samples were analyzed for methylmercury
- Air sampling was carried out in accordance with methods developed specifically for the collection of atmospheric mercury (Section 2.7).

The Phase IA modifications approved prior to the initiation of fieldwork are summarized below:

- An EnCore[®] sampling device was used for sampling VOCs in borehole soil
- Monitoring well MW-15 was relocated to the southern corner of the U.S. Life Warehouse because of restricted access at the proposed location.
- Selected soil samples from offsite boreholes B-9 through B-13 were submitted for laboratory analysis.

Activities performed in accordance with these modifications are not considered deviations from the Work Plans (CRA 1996; Exponent 1999, 2002). Tables 2-1 and 2-2 present summaries of laboratory analyses conducted for each field sampling component. References to the Phase I Work Plan in the following sections refer to the RI/FS work plan prepared by CRA (1996).

2.1 Phase I Surface Soil Investigation

2.1.1 Onsite Surface Soils

2.1.1.1 Objectives

The objectives of this investigation were to determine the distribution of SoPCs, if any, in shallow soil, and based on the results of the OU1 soil data, to develop a list of targeted substances for analysis of samples collected during the offsite surface soil investigation (see Section 2.1.2). Results of the OU1 surface soil chemical analyses are provided in Appendix B1, Table B1-1. The results of the OU2 marsh soil chemical analyses are provided in Appendix B2, Table B2-3. The field methods for the collection of OU2 marsh soils are discussed in the following subsection, although these samples will be discussed as sediment in this report. The onsite surface soil investigation was conducted from October 23 through November 6, 1997.

2.1.1.2 Approach

Surface soil samples were obtained from 0–2 ft below ground surface (bgs) at 200-ft intervals on the control grid. However, due to physical obstructions at certain locations, samples could not be taken in exact accordance with the grid. The field team conducted a Site walk with Mr. Stephen MacGregor of the NJDEP on October 14, 1997, to review the soil sampling locations. With approval from Mr. MacGregor, five locations within the

developed area and three locations within the undeveloped filled area were adjusted because of surficial obstructions. Additionally, eleven of the grid locations in the marsh area fell in Berry's Creek or the Diamond Shamrock/Henkel Ditch (south). These locations were moved to the nearest non-inundated point on the Site. The actual positions of all sample locations are illustrated in Figures 2-1a through 2-1e.

Samples were collected with a 2-ft-long, 3-in.-diameter split-spoon sampler. In the developed area and the undeveloped filled area, split-spoon samplers were driven using a compressed-air-powered jackhammer. Where the surface was covered with asphalt pavement, a compressed-air-powered jackhammer was used to remove the pavement before driving the split spoon. In the marsh area, split-spoon samplers were advanced manually using a sledgehammer.

Contents of the split-spoon sampler were visually inspected and screened with an Hnu Model P-101 photoionization detector (PID) with an 11.7-electron-volt lamp. The 0.5-ft interval that exhibited the highest field screening readings was collected and subsequently analyzed for target compound list (TCL) VOCs. If no elevated readings were observed, the interval from 1.5 to 2.0 ft bgs was sampled for VOCs. The remainder of the soil material was homogenized and sampled for the remaining analytes. After sampling, boreholes were backfilled with the unused contents of the split-spoon sampler. Locations in the developed area where samples were taken beneath the asphalt pavement were also backfilled and covered with an asphalt patch. Soil sampling logs, with physical descriptions and PID readings for each sample, are provided in Appendix C. Surface soil was collected from 52 onsite locations (SS-01 through SS-52) that are shown on Figure 2-1b.

2.1.1.3 Deviations from the Work Plan

No significant deviations from the Work Plan occurred during the onsite surface soil investigation.

2.1.2 Offsite Surface Soils

2.1.2.1 Objective

The objective of the offsite surface soil investigation was to characterize the distribution of Site SoPCs, if any, on adjacent properties to the north of the Site. The Site-specific indicator chemical list was developed based on the results from the onsite surface soil samples. This list was submitted to NJDEP in an April 2, 1998, letter from Exponent to Gwen Zervas, and the list was subsequently approved by NJDEP on April 23, 1998. Targeted analytes for the offsite soils included seven SVOCs and seven metals (see Table 2-1 for the list of target analytes). Results of the offsite surface soil chemical

analyses are provided in Appendix B1, Table B1-6a. Offsite surface soil samples were collected on May 6 and 7, 1998.

2.1.2.2 Approach

Offsite surface soil samples were collected from 0–6 in. bgs. A new control grid with 200-ft intervals in the offsite sampling area was established during sample collection. Several locations were shifted away from the grid due to the presence of physical obstructions, such as railroad tracks, buildings, and underground utilities.

Samples were collected using a 2-ft split-spoon sampler or a stainless-steel hand auger, depending on ground surface and soil type. Where appropriate, samples were obtained directly from the soil surface. If present, surface cover material such as pavement, gravel, grass, or other fill material was removed using a compressed-air-powered jack hammer or a shovel, as appropriate, to expose the surface of the native soil. Samples were collected from the 0- to 6-in. interval below surface cover material. After sampling, boreholes were backfilled with the leftover sample material. Locations where samples were taken beneath the asphalt were subsequently covered with an asphalt patch. Surface soil was collected from 22 offsite locations (SS-53 through SS-74) and are shown in Figure 2-1b.

2.1.2.3 Deviations from the Work Plan

Sample locations were not surveyed prior to sampling. In response to this situation, sample locations were estimated in a manner that preserved approximately uniform coverage of the planned sampling area and the planned number of samples. Sample locations were marked clearly and subsequently surveyed. The actual positions of all offsite soil locations are depicted in Figure 2-1b.

2.2 Phase I Subsurface Soil Investigation

2.2.1 Geophysical Survey

2.2.1.1 Objective

The objective of the geophysical survey was to identify geophysical anomalies in the filled area of the Site where buried metallic objects (such as drums) could potentially be located. The results of the survey, combined with information about past Site activities, as described in the BITM (Volume 4), were used to select locations for test pits to verify the presence of any buried metallic objects. The geophysical survey methods and results were fully documented in the report entitled *Geophysical Investigation Report*,

Ventron/Velsicol (Wood-Ridge) NPL Site, Wood-Ridge, New Jersey (BBL 1998), which was submitted to the NJDEP in January 1998. The following is a brief summary of the geophysical survey procedures. The geophysical survey was conducted from October 13 through October 22, 1997.

2.2.1.2 Approach

Electromagnetic induction data were acquired using an EM-31 Terrain Conductance Meter (EM-31) manufactured by Geonics, Ltd. Data were collected in the undeveloped filled area of the Site at 25-ft intervals on the 100×100-ft control grid. At each 25-ft interval, the in-phase and quadrature components of the electromagnetic field, described below, were recorded.

- The *in-phase component* measurements represent the ratio of the magnetic field induced by the EM-31 to the primary (site-related) magnetic field, reported in parts per thousand. These data provide a relative measure of the presence of buried metallic objects.
- The *quadrature component* is the apparent ground conductivity (terrain conductance) in millisiemens per meter. The quadrature data indicate areas of higher conductance compared to surrounding areas.

For each component, data were collected in both the vertical and horizontal dipole modes. The vertical mode measures to a depth of 6 m bgs. The horizontal mode measures to a depth of approximately 3 m bgs. The horizontal mode data were collected as a matter of routine, but did not satisfy the survey objectives of detecting potential buried material throughout the entire filled interval at the Site, and so were not used in data interpretation.

When data acquisition was complete, the field measurements were entered into an electronic spreadsheet, and then imported into the Geosoft[®] program to create contour maps using the contouring algorithm in Geosoft[®]. These contour maps are included in the *Geophysical Investigation Report* (BBL 1998). The contour maps were used to identify anomalies in the vertical dipole mode in-phase measurements and the vertical dipole mode quadrature readings.

The *Geophysical Investigation Report* (BBL 1998) proposed 18 locations for test pits. In a letter dated February 11, 1998, to Mr. Norman D. Kennel (Velsicol), NJDEP requested two additional test-pit locations, which were subsequently added to the test-pit program. The excavation of these test pits is discussed in Section 2.2.2.

2.2.1.3 Deviations from the Work Plan

No significant deviations from the Work Plan occurred during the geophysical survey.

2.2.2 Test Pits

2.2.2.1 Objectives

The objectives of the test-pit excavation program were to evaluate the potential presence of buried metallic material at the geophysical anomalies identified during the geophysical survey, to obtain subsurface soil samples from the locations of the anomalies (see Section 2.2.3), and to obtain information to support the hazardous substance inventory (see Section 2.8). The test pits were excavated from March 16 through March 18, 1998.

2.2.2.2 Approach

Test pits were excavated using a tracked excavator. A steel plate was welded across the teeth on the excavator bucket to minimize the possibility of damaging any buried containers. A field team observed and directed the excavation activities, monitored air quality for gaseous mercury and organic vapor, and collected samples of soil and other materials. Each test-pit excavation was documented with photographs and observations recorded in test-pit logs (Appendix D).

Each test pit was located near one or more geophysical anomalies identified during the geophysical survey (see Section 2.2.1). To minimize the possibility of damaging buried containers located near the center of each anomaly, excavation began approximately 15 ft from the center of the anomaly, and extended toward the anomaly. Soil was excavated in 1-ft lifts. The excavated soil was placed on polyethylene sheeting adjacent to the test pit. Each test pit reached to the water table, native soil, or 10 ft bgs, whichever was shallower. Soil sampling conducted during test-pit excavation is described in Section 2.2.3 of this report. Observations for the hazardous substance inventory (see Section 2.8) were also made at this time.

When observations and sampling at each test pit were complete, the test pit was backfilled with the excavated material to within 1 ft of the ground surface. The remainder of the test pit was filled with clean, imported sand. Any compromised or leaking containers encountered during test-pit excavation were removed, sampled, overpacked, and staged in the temporary drum staging area located near the decontamination pad. The excavation equipment was decontaminated by steam cleaning at the onsite decontamination pad at the completion of test pit excavation activities. The steam cleaning rinsate was released to the ground surface at the Site. The locations of all

20 test pits were subsequently surveyed (TP-01 through TP-20) and are shown on Figure 2-1e.

2.2.2.3 Deviations from the Work Plan

No significant deviations from the Work Plan occurred during excavation of the test pits.

2.2.3 Soil Sample Collection and Analysis

2.2.3.1 Objective

The objective of the subsurface soil sampling program was to determine the distribution of SoPCs, if any, in subsurface soil in areas potentially associated with buried materials. The results of this subsurface investigation are provided in Appendix B1, Tables B1-4a, B1-4b, B1-4c, and B1-5. Subsurface soil samples were collected in conjunction with the test-pit excavations from March 16 to March 18, 1998.

2.2.3.2 Approach

Soil samples were obtained from approximately 0–2 ft and 2–4 ft above the base of each test pit. In addition, nine discretionary samples were collected from areas of visible contamination. To collect sample material, the excavator bucket was used to scrape the walls of the test pit at the selected depth. Samples intended for TCL VOC analysis were collected by placing soil (or other material) from the excavator bucket directly into sample jars, and avoiding any soil that had contacted the bucket itself. Samples intended for all other analyses were collected by transferring soil from the excavator bucket, avoiding any soil that had contacted the bucket itself, into a stainless steel bowl for homogenization and transfer to sample jars. Two subsurface soil samples were collected from 18 of the 20 test pits. Only one subsurface soil sample was collected from each of two test pits that were very shallow (less than 3 ft). A total of 38 subsurface soil samples and 9 discretionary samples were collected.

2.2.3.3 Deviations from the Work Plan

No significant deviations from the Work Plan occurred during subsurface soil sampling.

2.3 Phase I Hydrogeological Investigation

2.3.1 Groundwater Surface Elevation Measurements

2.3.1.1 Objectives

The objectives of this task were to determine the groundwater surface elevation and flow direction, and to assess the effect of tidal water-level changes in Berry's Creek on Site groundwater surface elevation and flow direction. The hydrogeological investigation was performed in stages beginning on October 15, 1997, and intermittently through January 16, 1998.

2.3.1.2 Approach

The major elements of this task were surveying the locations and elevations of the 12 existing monitoring wells and three existing piezometers; redeveloping the wells and piezometers; conducting three rounds of synoptic water-level measurements; and conducting a tidal fluctuation study. The surveying and elevation measurements were recorded by Stewart, as indicated in Section 2.9. The monitoring well locations (MW-1 through MW-12) are shown on Figure 2-1a. Each of the other elements is described below.

2.3.1.3 Well Redevelopment

Monitoring wells and piezometers, except MW-4, were redeveloped from October 15 through October 17, 1997. Monitoring well MW-4 was not located during the initial redevelopment activities because of the dense overgrowth in this area of the Site. It was subsequently located and redeveloped on November 11, 1997.

Prior to redevelopment, the well casings were inspected, and the air in the well casing was monitored with a PID and a Jerome mercury meter. The depth to water and the depth to the bottom of each well were measured with an oil/water interface probe. A permanent mark was established on the inner well casings as a reference for depth-to-water measurements, if no mark was present.

During redevelopment, the pH, specific conductance, and temperature of the redevelopment water were measured. Redevelopment continued for 4 hours, or until the pH, specific conductance, and temperature had stabilized within 5 percent for three consecutive readings. The redevelopment water from wells MW-1 through MW-7 and MW-12, located in the undeveloped filled area of the Site, was discharged onto the ground surface in the vicinity of each well. The redevelopment water from wells MW-8

through MW-11, located in the developed area of the Site, was collected in drums and subsequently discharged to the ground surface in the undeveloped filled area.

2.3.1.4 Groundwater Level Measurements

Synoptic rounds of water-level measurements were made on the following dates: October 15, 1997; December 9, 1997; and January 15, 1998. Each round of water-level measurements included all onsite monitoring wells and Berry's Creek upstream (north) and downstream (south) of the tide gate. Depth-to-water measurements were made with an electronic water-level indicator from the reference points on the inner casing of each well. At Berry's Creek, the measurements were made from the surveyed reference point on the deck of the tide gate. Water levels were measured to an accuracy of 0.01 ft. Prior to each use, the bottom 3 ft of the water-level indicator was rinsed with acetone and distilled water.

2.3.1.5 Tidal Study

The tidal study was conducted from January 14 through January 16, 1998. Monitoring wells MW-1, MW-2, MW-4, MW-6, MW-7, and MW-12, and Berry's Creek upstream and downstream of the tide gate were included in the tidal study. Troll™ combined data loggers and pressure transducers, manufactured by In Situ, Inc., were installed in each well. Water-level measurements were recorded by the Trolls™ at 15-minute intervals to an accuracy of 0.001 ft.

During the tidal study, an electronic water-level indicator was used to make water-level measurements of Berry's Creek above and below the tide gate from the surveyed reference point on the tide gate. The electronic water-level indicator was also used to measure the depth to water at least two times per day in the monitoring wells as a check on the data recorded by the Trolls™. The time and water-level data stored in the Trolls™ were downloaded for subsequent interpretation. The complete data set is provided in Appendix E.

2.3.1.6 Deviations from the Work Plan

Each well was pumped using a decontaminated submersible pump. To maintain the integrity of the pump's material, the acetone and nitric acid rinses were excluded from the standard decontamination procedure, as described in the revised FSP (Appendix A).

Water-level measurements were not made continuously over three tidal cycles at two locations in Berry's Creek as stated in the FSP. The electronic water-level indicators were suspended from the tide gate and could not be left unattended. Water-level

measurements in Berry's Creek were made over the course of three days when field staff were onsite.

2.3.2 Aquifer Parameter Tests

2.3.2.1 Objective

The objective of the aquifer tests was to determine the hydraulic conductivity of the materials immediately adjacent to each onsite monitoring well and thus provide approximate values across the Site. The results of this investigation are presented in Section 3.6, Groundwater Hydrogeology. These tests were conducted on January 15, 16, and 19, 1997.

2.3.2.2 Approach

Rising-head slug tests were completed at each onsite monitoring well in accordance with the method of Bouwer and Rice (1976). An 8-ft-long, 1-in.-diameter slug was used for the tests. The slug was introduced into each well, and the water level was allowed to equilibrate. The change in the water levels in the wells in response to the removal of the slug (a rising-head test) was measured with a pressure transducer immediately after removing the slug, and was recorded at logarithmic time intervals by a HermitTM electronic data logger manufactured by In Situ, Inc. Two rising-head tests were completed at each monitoring well except MW-6, as discussed below. The time and head measurements were downloaded and analyzed using the Bouwer and Rice (1976) solution for hydraulic conductivity in an unconfined aquifer with the Aqtesolv[®] (Duffield 1996) software package.

2.3.2.3 Deviations from the Work Plan

The water-level recovery time in well MW-6 was more than 90 minutes. It was determined that one measurement would provide an accurate estimate of the hydraulic conductivity at this location, because any minor difference in the recovery time would not be significant.

2.3.3 Sample Collection and Analysis

2.3.3.1 Objective

The objective of groundwater sampling and analysis was to determine the distribution and concentration of SoPCs, if any, in Site groundwater. Results of the groundwater chemical analysis are provided in Appendix B1, Table B1-7a, B1-7b, and B1-7i. Groundwater sampling was performed from November 10 through November 17, and on November 25, 1997.

2.3.3.2 Approach

Groundwater samples were collected at all monitoring wells using the low-flow purging and sampling method. Sampling occurred at least two weeks after redevelopment of these wells. Water quality parameters were measured during well purging, before sampling, and after sampling. These measurements are provided in Appendix F. When purging was complete, groundwater samples were collected directly into laboratory-prepared bottles. Samples intended for analysis of methylmercury and TAL metals (which includes mercury) were collected using an ultra-clean technique to minimize contamination, as described in the revised FSP (Appendix A).

One set of samples was collected from each monitoring well, for a total of 12 sets of groundwater samples. The well locations (MW-1 through MW-12) are annotated on Figure 2-1a.

2.3.3.3 Deviations from the Work Plan

No significant deviations to the Work Plan occurred during groundwater sampling.

2.4 Phase I Leachate/Seep Sampling

2.4.1 Objective

The objective of the leachate/seep sampling was to assess the transport of SoPCs, if any, from the Site via drainage from stream banks into adjacent streams. The stream banks are exposed and the seeps are accessible during low tide. The seeps likely consist of a blend of groundwater and surface water that has infiltrated the stream banks during high tide. The analytical results are provided in Appendix B1, Tables B1-8a and B1-8b. The leachate/seeps investigation was conducted on October 15 and 16, 1997.

2.4.2 Approach

Field reconnaissance identified the presence of numerous small seeps along the banks of the undeveloped portion of the Site. Five seep locations were selected: three in Berry's Creek, and two in the Diamond Shamrock/Henkel Ditch (north). Seeps were identified by visual inspection of the banks and subsequent confirmation that water was not originating from a muskrat's burrow. Each seep was sampled at low tide by collecting the water directly into the sampling containers. In some circumstances where the slope of the bank was fairly shallow, a small sump was constructed beneath the seep, allowing the water to accumulate and thereby assist with the transfer of seep water into sample containers. The locations of the five seep samples (SE-01 through SE-06) are shown on Figure 2-1d. (Results for sample location SE-04 are the average of duplicate samples SE-04 and SE-05. Thus, no sample location exists for SE-05.)

2.4.3 Deviations from the Work Plan

The Work Plan states that NJDEP will identify the appropriate locations for leachate/seep sampling. Staff from NJDEP selected one seep location in the Diamond Shamrock/Henkel Ditch (north); the other four seep locations were selected by field staff with approval from NJDEP. The incoming tide disrupted the sampling at locations SE-04 and SE-06. Sampling at these locations continued on the following day during low tide.

2.5 Phase I Surface Water and Sediment Investigation

2.5.1 Objectives

The objective of the surface water investigation was to determine the distribution of SoPCs, if any, in surface water from water bodies in and surrounding the Site, and the variability of these substances during three tidal stages in Berry's Creek. Results of the surface water chemical analyses are provided in Appendix B1, Tables B1-9a; and Appendix B2, Tables B2-1a and B2-1b. Surface water sampling was conducted on October 31, 1997, and November 12, 1997.

The objective of the surface sediment investigation was to determine the distribution of SoPCs in the upper 15 cm of the sediment, and the total mercury concentrations in the upper 2 cm of sediment. Results of the sediment chemical analyses are provided in Appendix B1, Tables B1-10a and B1-10b; and Appendix B2, Table B2-2. Sediment samples from the onsite basin were collected on November 5, 1997. Sediment samples from Berry's Creek and the Diamond Shamrock/Henkel Ditch (north) were collected on five days between October 30 and November 12, 1997.

2.5.2 Approach

Surface water samples were collected by submerging individual sample containers (approximately 10 cm below the water surface) and allowing them to fill. Care was taken not to disturb the surface sediment beneath the surface water to limit the amount of solids collected in the sample. Surface water collection for mercury and methylmercury analysis was performed using the ultra-clean technique described in the revised FSP (Appendix A).

The upper 15 cm of sediment was collected using either an Ekman grab sampler or a stainless-steel spoon, when low tide allowed direct access to the surface sediment. Additionally, the top 2 cm of sediment was collected from a second grab sample for analysis of mercury only. Descriptions of each sediment sample and the sampling conditions can be found in Appendix G.

Surface water and sediment samples were collected at a total of nine sample locations (see Figure 2-1d). Two locations were in the onsite basin: one near the west edge and the other near the east edge. To avoid resuspending and disturbing sediment in the onsite basin, samples were collected near the edges where sediment accumulation was abundant. Sediment was collected to depths of 14 and 14.5 cm. The other onsite locations were in the Diamond Shamrock/Henkel Ditch (north) at three locations spaced approximately evenly along the ditch. Surface water and sediment were collected from four locations in Berry's Creek: 1) just upstream of the railroad bridge at the northeast corner of the Site, 2) upstream of the tide gate, 3) half-way between the tide gate and the confluence with the Diamond Shamrock/Henkel Ditch (north), and 4) upstream of the confluence with Nevertouch Creek. Each of the four locations in Berry's Creek was sampled at high, mid, and low tide during a single ebb tide. A total of 17 surface water samples and 9 surface sediment samples were collected at 9 sample locations (SW-01 through SW-09 and SD-01 through SD-09) shown on Figure 2-1d.

2.5.3 Deviations from the Work Plan

Surface water collection for all three tidal stages at SW-04 occurred on November 12, 1997, twelve days after the other three upstream Berry's Creek locations. On the initial sampling attempt, the high and mid-tide samples were inadvertently collected in Nevertouch Creek, rather than in Berry's Creek. During high tide, the whole area was flooded, and the features on the map used to locate the sample location were not apparent. The navigational error was realized during sampling at low tide.

The Work Plan states that sediment collection is to be performed using a core sampler and that all sediment should be collected on one occasion during the three surface water sampling events (i.e., high, mid, or low tide). Sediment collection was performed using an Ekman grab sampler, rather than a core sampler, due to sample volume requirements. Field personnel determined that sediment collection during a single tidal period was not

only infeasible due to time restrictions; it also did not follow sound sampling protocols. Sediment sampling causes significant disturbance to, and resuspension of, the surface sediment. Therefore, it was not appropriate to collect water samples at the same time as sediment samples.

2.6 Phase I Wetlands Investigation

2.6.1 Objectives

The objectives of the survey were to delineate and describe the wetlands contained on the Site. The initial survey for the wetlands investigation was conducted on May 22, 1997, by Shisler Environmental Consultants, Inc. The complete report from the wetlands investigation has been provided by Shisler Environmental Consultants under separate cover (*Wetland Delineation Report*, Shisler 1997). The results of the investigation have been reviewed and jurisdictional acreage confirmed by the U.S. Army Corps of Engineers (ACOE), New York District.

2.6.2 Approach

Wetlands are defined as “those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.” Wetlands generally include “swamps, marshes, bogs, and similar areas” (40 CFR § 122.2). Wetlands on the Site were delineated through visual inspection using the multi-parameter approach: hydric soils, hydrophytic vegetation, and wetland hydrology. Wetlands were classified according to Section 404 of the Rivers and Harbor Act of 1899 and Section 10 of the Clean Water Act.

During the Site inspection, vegetation and topography were examined to identify changes that would indicate the potential presence of wetlands. Soil borings were performed to confirm the presence of hydric soils if vegetation and hydrology suggested wetland conditions. The wetland boundary was flagged at 75- to 100-ft intervals, and these flags were subsequently surveyed and plotted on a topographic Site map (See Plate 15 from Shisler 1997).

2.6.3 Deviations from the Work Plan

No deviations to the Work Plan occurred. Review of the jurisdictional wetlands by the ACOE on June 22, 1998, resulted in additional classification of Section 10 wetland acreage between the warehouses on the developed portion of the Site.

2.7 Phase I Air Sampling

2.7.1 Objective

The objective of the air sampling was to determine the concentration of gaseous and particulate mercury in ambient air at the Site. The results of air sampling are provided in Appendix B1, Table B1-11a. The first round of air sampling was performed prior to the initiation of field activities (September 4 and October 14, 1997). Although not required by the Work Plan (CRA 1996), a second round of air sampling, for gaseous mercury only, was performed during the test-pit excavations (March 16–18, 1998).

2.7.2 Approach

During the first round of air sampling, ambient, 8-hour air samples were collected at four locations in the developed area of the Site, and one in the undeveloped filled portion of the Site. Air samples were collected at locations A-1 through A-5, shown on Figure 2-1c. Location A-3 was the background location and was selected based on the wind direction on the day of sampling.

Two pumps were used at each sampling location to obtain the air samples. MSA Flow-Lite Pro personal sampling pumps were fitted with iodated carbon traps to collect atmospheric gaseous mercury at flow rates of 2 liters per minute (Lpm). Quartz wool plugs were placed in front of the traps to exclude any atmospheric particulate material. In addition, Gilian AirCon-2 or Dawson High Volume air samplers were fitted with quartz fiber particulate filters to collect particulate mercury samples at flow rates of 20 Lpm. A Gilian Gilibrator calibrator was used to calibrate the flow rate through the pumps before and after the sampling period.

The second round of sampling was conducted to monitor the ambient air during the test-pit excavations. Six samples were collected from the perimeter of the undeveloped filled area of the Site. As in the first round of sampling, iodated carbon traps were used to collect gaseous mercury with SKC low-flow pumps (Model 224 TCXR4) at flow rates of 2 Lpm. An M-5 mini-Buck Calibrator was used to calibrate the pumps at the beginning and end of each sampling day. Each trap sampled air during the three days while the test pits were being excavated. When no excavations were taking place, the traps were capped and stored overnight in sealed double bags using ultra-clean handling techniques. The air sampling logs are included in Appendix H. The six sampling locations (B-1 through B-6) are shown on Figure 2-1c.

2.7.3 Deviations from the Work Plan

The Work Plan specified that nuisance dust was to be determined gravimetrically on the particulate filter. The 8-hour sampling period was too short to provide enough particulate material on the filter for a precise measurement of nuisance dust. Only the concentration of elemental mercury in particulate form was measured on the filter.

The sampling pump at location A-4 did not run for eight hours on September 4, 1997, so sampling was not completed at this location. BBL returned to the Site and recollected the sample at this location on October 14, 1998. All sampling and analytical procedures were the same as those conducted for the other sample locations on September 4, 1997.

A second round of air sampling was conducted during the test-pit excavation to monitor the Site's perimeter for gaseous mercury during trenching activities.

2.8 Phase I Hazardous Substance Inventory

2.8.1 Objectives

The objective of the hazardous substance characterization task was to inventory all potentially hazardous substances encountered in the undeveloped filled area during the Site investigation. In addition, leaking contents and compromised drums exhumed during the test-pit excavations were to undergo hazardous waste characterization analysis, for the purpose of determining appropriate management of the exhumed materials. The results of these analyses are presented in Appendix B1, Table B1-12. Information regarding buried potentially hazardous substances was collected during the excavation of test pits from March 16 through March 18, 1998. Information regarding potentially hazardous substances located on the ground surface was obtained during a thorough Site walk on March 18 and 19, 1998.

2.8.2 Approach

During the test-pit excavations, three compromised drums were encountered and sampled. These samples were submitted to the lab for full waste characterization analysis. Only one of these drums was in good enough condition to be removed and overpacked; the other two were too severely deteriorated. During the Site walk, samples were collected from three surface drums and four potentially hazardous surface samples. The sampled materials, as well as any other potentially hazardous material, were described in the field notes and photographed. All sample descriptions are contained in the hazardous substance inventory logs (Appendix I), and the analytical results are reported in Appendix B1, Table B1-12. The locations of the surface drums and surface samples (HS-1 through HS-7) are shown on Figure 2-1e.

2.8.3 Deviations from the Work Plan

No deviations from the Work Plan occurred during the hazardous substances characterization task.

2.9 Phase I Topographic and Location Survey

2.9.1 Objectives

The objectives of the surveying services were to: 1) establish a 100×100-ft control grid in the undeveloped filled portion of the Site; 2) establish the horizontal positions for sample locations, wetland delineation, geophysical survey, and other Site features; 3) establish vertical positions of surface water and groundwater elevation measurement locations; 4) determine the Site boundary and locations of nearby physical and cultural features; and 5) determine the Site topography. Surveying activities were performed at the Site between October 1997 and May 1998.

2.9.2 Approach

A State of New Jersey licensed land surveyor performed all surveying work on the Site. The control grid was established prior to onsite surface soil sampling. Each grid point was marked with a 2×2-in. wooden survey hub, and by an adjacent survey pin flag for greater visibility. All surveyed locations were established to within 0.01 ft using the New Jersey Plane Coordinate System datum. Vertical elevations were established to within 0.01 ft using the National Geodetic Vertical Datum of 1988. Horizontal and vertical control originated from the nearest New Jersey Geological Survey monument. All survey data were transferred electronically to Exponent in AutoCAD format. A “leaf-off” aerial photograph of the Site was taken November 27, 1997, and was used to prepare the topographic survey. Plate 1 depicts the Site topography, and the aerial photograph is the basis of the Site map, Figure 1-2.

2.9.3 Deviations from the Work Plan

No significant deviations from the Work Plan occurred during the topographic and location survey.

2.10 Phase I Cultural Resources Investigation

2.10.1 Objective

The objective of the cultural resources investigation was to discover any potential historical or cultural resources contained within the Site that could be disturbed through remediation and development. The results of the study were presented previously in a separate bound report, *Phase IA Cultural Resource Investigation, the Wood-Ridge Site* (CRCG 1997). The investigation of the cultural resources at the Site occurred in June and July of 1997.

2.10.2 Approach

In accordance with Section 106 of the National Historic Preservation Act, a Phase IA (reconnaissance level) cultural resource survey was conducted. A visual reconnaissance of the Site was conducted, and an extensive body of literature pertaining to the Site specifically, and to the region as a whole, was reviewed to evaluate the cultural and historical value of the Site.

The literature review covered a wide range of topics and time periods. Records were examined for evidence of cultural resources ranging from prehistoric occupation, to early European settlement, to construction of modern turnpikes. Sources contained information on topics such as agriculture, mosquito control, railroad construction, commercial development, and land use planning. The background research was conducted using State files, historical maps, USDA soils information, and various other secondary sources.

The visual reconnaissance was conducted on July 2, 1997, with the purpose of identifying any visible surface signs of cultural resources, examining the environmental setting, and determining the extent of ground disturbance. Inspection of the Site's perimeter, architectural features, topographic anomalies, areas of ground disturbance, and clearing were key components of the Site inspection.

2.10.3 Deviations from the Work Plan

No significant deviations from the Work Plan occurred during the cultural resources investigation.

2.11 Phase IA Cutoff/Containment Wall Investigation

2.11.1 Objectives

The objective of the cutoff wall investigation was to confirm the reported presence of a containment wall along the eastern and southern property boundary of Lot 10B (Wolf Warehouse property).

2.11.2 Approach

The cutoff wall investigation approach included a file search and a subsurface investigation. Records at the Borough of Wood-Ridge and other sources, including pretrial memoranda, letters, and personal communications were examined. Appendix O presents a summary and copies of the documents reviewed. The records review indicated that either Alternative 2 or Alternative 3, as shown on Figure 2-2, had been constructed. Following the records search, as requested in a May 18, 2000 letter from Gwen Zervas (NJDEP) to Andy Myslicki (NWI), a subsurface investigation using excavation equipment was conducted to confirm the existence and location of the cutoff wall.

The containment wall subsurface investigation was conducted by observing underground conditions in excavations at the five locations shown in Figure 2-2. These locations were selected to both generally verify the presence of the wall and determine whether Alternative 2 or 3 was constructed. The presence of the railroad tracks and ditch in the narrow space between the buildings and the fence line (coincident with the property line) prevented investigation of the containment wall along the southwestern side of the warehouse building. These locations were also chosen to minimize any disruption of business activities at the Wolf warehouse.

These exploratory excavations generally followed the test pit/trench procedures outlined in Section 5.1.3 of the FSP (Appendix A). Initially, trenching was conducted perpendicular to the wall. Once the wall was encountered, the excavation advanced parallel to the wall down to the bottom of the wall along one side of the wall only. Supplemental manual excavation was used as needed to avoid damage to the wall. When each excavation was completed, the excavation was backfilled with the stockpiled soil, covered with clean sand, and graded to restore the area to its original condition. Section 3.4.1 discusses the results of this investigation.

2.11.3 Deviations from the Work Plan

The Supplemental Phase IA Work Plan (Exponent 2000b) proposed two, excavation locations. Based on field decisions, confirmed with the Agency representatives on Site

during the excavation, five locations were excavated. The originally planned locations are shown as locations 1 and 5 on Figure 2-2.

2.12 Phase IA Field Investigation

2.12.1 Objectives

The objective of the Phase IA investigation was to address issues identified by the Respondents in the December 1998 agency review draft remedial investigation report (Section 8.3), NJDEP and EPA comments presented in NJDEP's April 1, 1999 and November 1, 2001 letters, and other data needs that were subsequently identified.

2.12.2 Approach

The Phase IA remedial investigation included the collection of soil, sediment, groundwater, seep, and surface water samples from the developed and undeveloped filled areas of the Site. Periodic groundwater surface elevation measurements were also taken in each onsite monitoring well. These investigations were performed in accordance with approved work plans (Exponent 1999, 2002) with the exception of some modifications noted below. Figures 2-1a through 2-1e include the locations of all samples collected during the Phase IA remedial investigation.

2.12.2.1 Well Installation

Three new groundwater monitoring wells (MW-13, MW-14, and MW-15) were installed during November 19 and 20, 1999. During the installation of the wells, soil samples from the boreholes were collected continuously to the water table with a 2-ft-long split-spoon sampler. The well boring logs and the monitoring well as-built data for these new wells are provided in Appendix K. Samples for VOC analysis were collected using an EnCore[®] sampling device. Results of the borehole soil chemical analyses are provided in Appendix B1, Table B1-2a and B1-2b.

MW-13 was installed on November 20, 1999. The location of MW-13 was moved approximately 10 ft closer to the Wolf Warehouse than proposed because overhead power lines adjacent to Ethel Boulevard interfered with the drill rig. Prior to the collection of borehole soil samples, the overlying asphalt paving material and gravel fill was removed. Soil samples for the target metals and VOCs were collected in 2-ft intervals beginning at 1 ft bgs until the water level was reached at 7 ft bgs. Mercury vapor was detected in soil from the 1–3 and 3–5 ft intervals, although no beads of inorganic mercury were visible. Duplicate samples for mercury, in addition to samples

for target metals and VOCs, were collected from these intervals to measure sample variability for mercury. A third set of soil samples was collected from the 5–7 ft interval.

MW-14 was installed on November 19, 1999. Borehole soil samples for the target metals and VOCs were collected from the 0–2 and 2–4 ft bgs intervals. Water was encountered at 4 ft bgs. Two additional soil samples for mercury were collected at the 5–6 and 6–7 ft intervals to measure the vertical extent of mercury in the soil below the fill material, which extended to approximately 6 ft bgs. The 4–5 ft bgs interval consisted predominantly of ceramic tile and glass debris and was not analyzed.

MW-15 was installed on November 19, 1999. The proposed location of MW-15 was directly between the U.S. Life Warehouse and the Norfolk Southern Railroad spur, approximately 50 ft from the southern corner of the warehouse. Because of problems with access to this proposed location and possible interferences with the warehouse foundation, with concurrence from Gwen Zervas, NJDEP, and Matt Fox, EPA, MW-15 was installed near the southern corner of the U.S. Life Warehouse. Water was encountered at 0.75 ft bgs. One borehole soil sample was collected from the 0–2 ft bgs interval for the target metals and VOCs. An additional soil sample was collected from the bottom 6 in. of the 2–4 ft interval where the soil color and texture changed from the overlying black silt with some fine sand to a grayish/green fine sand and silt. Initially a protective outer casing that extended 2 ft above the ground surface was installed at MW-15. At the request of Norfolk Southern Railroad, on November 30, 1999, this outer casing was cut down and replaced with a flush-mount-type cap set approximately 6 in. above ground surface to limit infiltration of surface runoff.

2.12.2.2 Phase IA Groundwater Sampling and Water Level Measurements

Groundwater samples were collected using the low-flow sampling protocol from the 15 Site monitoring wells during December 6 to 10, 1999 (see Section 2.3.3.2). Water quality parameters were measured both before and after sample collection at each well. Samples designated for mercury analysis were collected using the “clean hands” technique to minimize mercury contamination. Results of the Phase IA groundwater chemical analyses are provided in Appendix B1, Tables B1-7e, B1-7f, and B1-7k. All monitoring wells were checked for the presence of non-aqueous phase liquids (NAPL) prior to purging. None were encountered.

Additional groundwater samples were collected from MW-7, MW-13, and MW-15 on June 19, 2000, and from all wells again during September 24 to 27, 2002 as part of the supplemental Phase IA investigation and the Phase IA SFI. The same procedures described above were used for these sampling events, with two exceptions. Groundwater was collected from these wells using low-flow technique; however, both filtered and unfiltered samples were collected. Samples were field-filtered using a 0.45 μm pore-size in-line filter. In 2002, a peristaltic pump was used because volatilization was not a concern (i.e., samples were only analyzed for mercury). The June 2000 samples were analyzed for mercury only, and the September 2002 samples were analyzed for mercury

as well as selected metals (arsenic, barium, cadmium, copper, iron, lead, manganese, nickel, thallium, and vanadium) as requested by NJDEP. Results of the supplemental Phase IA groundwater chemical analyses in 2000 are provided in Appendix B1, Tables B1-7g, B1-7h, and B1-7i. Results of the Phase IA SFI groundwater chemical analyses in 2002 are provided in Appendix B1, Tables B1-7m, B1-7n, and B1-7o. NAPL was not encountered in any of the wells.

Groundwater surface elevations were measured before purging and sampling each well. Another set of measurements was taken on December 10, 1999, after sampling at all wells was complete. Second and third rounds of groundwater elevation measurements were performed on February 10, April 10, and June 19, 2000.

2.12.2.3 Phase IA Seep Sampling

Seep samples were collected the week of December 6, 1999. Sample locations were as close to the five seep sample locations sampled in Phase I as field conditions would allow. A small collection basin was constructed below each seep using a sheet of aluminum foil. Seep samples were collected from the basin using a 60-mL syringe after a sufficient volume of water had flushed through the basin and was running clear. Whole-water and field-filtered water samples were collected at each seep location. Samples were filtered in the field using a 25-mm, 0.45- μ m pore-size syringe filter. Samples designated for mercury analysis were collected using the “clean hands” technique to minimize mercury contamination. Results of the Phase IA seeps chemical analyses are provided in Appendix B1, Tables B1-8c and B1-8d.

2.12.2.4 Phase IA Surface Water and Sediment Sampling

Surface water and sediment samples were collected from three locations (SD-10, SD-11, and SD-12) in the West Ditch. Surface water samples were collected during high tide directly into the sample container from just below the air/water interface. Samples designated for mercury analysis were collected using the “clean hands” technique to minimize mercury contamination. Results of the Phase IA surface water chemical analyses are provided in Appendix B1, Table B1-9b. Surface sediment samples were collected from these same three locations using an Ekman[®] grab sampler after surface water samples were collected. Results of the Phase IA sediment chemical analyses are provided in Appendix B1, Table B1-10b.

2.12.2.5 Phase IA Offsite and Onsite Soil Sampling

Offsite surface soil samples were collected from four locations (SS-75, SS-76, SS-77, and SS-78) situated along a narrow strip of land west of the railroad tracks adjacent to Park Place East on January 12, 2000. Soil material from the 0–2 ft bgs and 2–4 ft bgs intervals

was collected using a hand auger. The presence of gravel, debris, and large rocks required some adjustment to the sample locations and limited sample penetration at SS-77 to 3 ft. The soil material from the top 0–2 ft at each location was homogenized, transferred to the sample container, and shipped to the analytical laboratory for mercury analysis. The material from the 2–4 ft interval at each location was homogenized, transferred to the sample container, and archived at the analytical laboratory for future potential analysis of mercury. Results of the Phase IA offsite surface soil chemical analyses are provided in Appendix B1, Table B1-6b.

Eight onsite boreholes (B-1 through B-8) and six offsite boreholes (B-9 through B-14) were advanced using a push-probe drill rig from October 8 to 10, 2002 and November 13, 2002 (Figure 2-1a). The onsite boreholes were located in the developed portion of the Site in areas surrounding the existing warehouse buildings. Soil samples were field screened during drilling for mercury vapor using a portable Jerome[®] mercury vapor meter. Soil samples collected from borehole B-5 from the 6–7, 7–8, 8–9, and 9–10 ft bgs intervals were shipped to the laboratory for mercury analysis due to field mercury vapor concentrations in excess of 0.5 mg/m³.

The offsite boreholes were located adjacent to the property boundary north of Ethel Boulevard. The three samples collected from the 0–6 ft bgs interval (i.e., 0–2, 2–4, and 4–6 ft bgs) were pre-selected for mercury analysis (although some intervals were not sampled due to insufficient sample recovery volume). Soil samples collected below 6 ft bgs were archived for potential analysis if the total mercury concentration in the 4–6 ft sample interval exceeded residential soil screening criteria.

The soil borehole logs are provided in Appendix K. Results of the onsite borehole soil chemical analyses are provided in Appendix B1, Tables B1-2a and B1-2b, along with the results of the Phase IA monitoring well borehole analyses. Results of the offsite borehole soil chemical analyses are provided in Appendix B1, Table B1-6c.

2.12.3 Deviations from the Work Plan

Surface elevation levels measurements above and below the tide gate in Berry's Creek were not performed during routine groundwater elevation measurements. The presence of ice in the creek made accurate measurements impossible during the December and February measurements. These measurements were also not performed in April. The tidal stage in the creek and ditch was noted during sampling and compared with the tidal stage predicted for that day.

Based on conditions encountered in the field, the following modifications were made:

- Monitoring well MW-13 was relocated approximately 10 ft closer to the Wolf Warehouse to maintain a safe distance between the overhead power lines and the drill rig

- No seep in the vicinity of former seep location SE-06 could be located, so a seep immediately downstream of SE-04 was sampled and is labeled SE-04A on Figure 2-1d
- Offsite sample locations SS-76 and SS-77 were adjusted to accommodate for obstructions encountered in this area.
- Borehole B-8 was relocated from the south corner of the Wolf Warehouse to the southeast side of the warehouse due to difficulty accessing the proposed location with the push-probe drill rig. Boreholes B-10 through B-14 were moved from their proposed locations to maintain a 25-ft offset from the railroad tracks as required by the Norfolk Southern Railroad. Relocation of the boreholes was approved by NJDEP (MacGregor 2002, pers. comm.).

2.13 Supplemental Warehouse Evaluation Study

2.13.1 Objectives

The objective of the warehouse evaluation study was to conduct air and soil sampling to assess potential inhalation exposure to the construction workers and to characterize the waste generated during the warehouse renovation work. Reddy Raw, a current tenant, conducted this renovation work in a vacant space within the U.S. Life warehouse.

2.13.2 Approach

Sampling occurred on four separate occasions between April 9 and April 21, 1999, prior to the scheduled renovation work at the U.S. Life (Jerbil) warehouse. General site reconnaissance and real-time air monitoring using a Jerome model 431-X mercury vapor analyzer was performed on April 9, 1999. Two sets of mercury vapor measurements were made at 15 locations at various elevations throughout the vacant warehouse where the renovations were planned. On April 12, 1999, three passive air samplers were placed in the vicinity of the small portion of exposed warehouse subfloor, and two passive air samplers were placed in opposite corners of the vacant warehouse. Additional real-time air monitoring was performed during this site visit. On April 13, 1999, after approximately 30 hours exposure time, the passive air samplers were retrieved and sent to Frontier Geosciences for total mercury analysis. Three soil samples from depths of 8 to 10 in. were collected from the fill material present in the exposed subfloor area. Soil samples were shipped to Cebam Analytical for total mercury analysis using the analysis method listed for offsite soil in Table 2-2. During this site visit, additional soil locations were staked out to encompass the area of proposed renovation work. Figure 2-3 presents the locations of samples collected during the warehouse evaluation study.

On April 20 and 21, 1999, a total of 18 soil samples were collected using a 2-ft-long split-spoon sampler. A compressed-air-powered jackhammer was used to remove 6-in.-square portions of the warehouse floor to expose the subfloor below. The split-spoon sampler was used to collect eleven soil samples from depths to approximately 18 in. from the fill material beneath the subfloor in the vacant warehouse. One soil sample was collected from inside the Reddy Raw warehouse where renovation work was planned. Six soil samples were collected from three locations at two different depths (0–2 and 2–4 ft) in the area described as the proposed compressor room adjacent to the Reddy Raw warehouse in the parking lot (see Figure 2-3). All soil samples were submitted to Cebam Analytical for total mercury analysis. A composite sample composed of soil from all warehouse locations was submitted to Accutest for RCRA waste characterization analysis. Aliquots of the six soil samples from the compressor room area were also submitted to Accutest for the same parameters specified for the borehole soil samples using the analysis methods listed in Table 2-2. Details of the warehouse evaluation study were provided in a memorandum from Exponent to Gwen Zervas, NJDEP, on April 30, 1999. Results of the warehouse evaluation soil sample chemical analyses are provided in Appendix B1, Table B1-3 and the air samples in Appendix B1, Table B1-11b.

2.13.3 Deviations from the Work Plan

The three soil samples collected on April 13, 1999, were collected from depth of 8–10 in. rather than the intended 15 in. The compact nature of the fill material in exposed subfloor made it difficult to achieve this depth using hand-sampling devices.

3.0 Physical Characteristics of the Site

Section 3 provides an overview of the physical characteristics of the Site, including information on its topography, geology, soils, hydrology, climate, land use, ecology, and demography. The information in this section is based on observations made during the Phases I and IA remedial investigations, from previous investigations, and available literature.

3.1 Topography and Surface Features

The 38-acre Site includes three distinctly different areas (see Figure 1-2): the 7-acre developed area, the 19-acre undeveloped filled area, and the 12-acre marsh area. The developed and undeveloped filled areas have been designated as OU1 and the remainder of the Site has been designated as OU2. The topography across most of the Site is generally flat, ranging in elevation from 0 to 12.6 ft above mean sea level (msl). The highest elevation is found near the middle of the undeveloped filled area, and the lowest elevation is found in the marsh area. Plate 1 shows the topography in 2-ft contours as developed from a November 1997 aerial photograph.

Two warehouses occupy most of the developed area of the Site. The rest of the developed area is covered by asphalt-paved surfaces, railroad tracks, or the ditch along the southwest side of a portion of the railroad tracks along the Wolf (Blonde) warehouse. The railroad tracks are located immediately behind the warehouses on a bed of gravel. The elevation of the developed area varies from 4.3 to 5.8 ft msl. The area between the warehouses contains a drainage ditch that is usually filled with water.

The undeveloped filled area of the Site is characterized by mixed vegetation and a variety of surficial debris. Much of this area is relatively flat, but the northeast portion of this area has uneven terrain. The highest point, 12.6 ft msl, is within 100 ft of the lowest point in the undeveloped filled area, at 3.4 ft msl. This low point is a small, rubble-filled pit. This rubble in the pit may include remnants of an access structure for the drainage system from the Plant area that extended to Berry's Creek. Another surface feature in the undeveloped filled area is a small basin. This basin may have been or may be a remnant of a settling basin for discharges from the Plant area or the Randolph Products property (see Section 2 of the BITM, Volume 4). Plate 1 shows the locations of the rubble pit and basin. The east and south perimeters of this area are steep stream banks adjacent to Berry's Creek and the Diamond Shamrock/Henkel Ditch (north), respectively. The north and west perimeters of the area are fenced; additional fencing to the east prevents Site access via the tide gate.

The marsh area contains a near-monoculture stand of common reed (*Phragmites*). A small drainage ditch extends lengthwise through the middle of the marsh area all the way

to Nevertouch Creek. The marsh area has the lowest overall elevation, with a maximum of 1.5 ft msl. At high tide, much of the marsh area is completely submerged. At low tide, the water drains, exposing sloping stream banks. Surface water hydrology is discussed more thoroughly in Section 3.5.

3.2 Climate and Meteorology

The climate in northeastern New Jersey is temperate continental (Trewartha 1968). Climate data cited in this report are from the National Oceanic and Atmospheric Administration data station located in Newark, New Jersey (15 miles south of the Site). The 1997 annual summary for this station can be found in Appendix J. The period of record for all climate data cited here is a minimum of 44 years.

Easterly winds, particularly southeasterly, moderate the temperature because of the influence of the Atlantic Ocean. The mean annual temperature is 54.2°F. July, the hottest month, has a mean maximum temperature of 84.6°F and mean minimum temperature of 66.9°F. January, the coldest month, has a mean maximum temperature of 38.5°F and a mean minimum temperature of 24.2°F (NOAA 1997).

Considerable amounts of precipitation fall during ocean-driven storms called Northeasters, which occur primarily in the autumn and winter. Annual precipitation averages 44 in., which includes 27 in. of snowfall. The driest month, February, has a mean precipitation of 3.0 in., and July, the wettest month, has a mean precipitation of 4.5 in. (NOAA 1997).

Low-lying ridges several miles to the northwest influence the winds flowing from the Atlantic Ocean over the region's generally flat, marshy terrain. Wind direction is predominantly from the northeast to the southwest, although during January through April, the wind tends to blow more from the southeast to the northwest. Annual average wind speed is 10.2 miles per hour, with higher-than-average wind speeds from January through April (NOAA 1997).

3.3 Geologic Setting

The Site is located in the Newark Basin, a rift basin that reaches from southern New York through northern and central New Jersey and into southeastern Pennsylvania. The southeastern and northwestern boundaries of the Newark Basin are defined by normal faults that strike northeast, between which the basin floor moved downward during the late Triassic Period (Carswell 1976).

The Newark Basin contains sedimentary rocks that were deposited during the Triassic and Jurassic Periods as the rift expanded to the northwest and southeast, and the center of the rift deepened. These sedimentary rocks consist primarily of sandstone and shale.

During the Jurassic Period, igneous rocks were emplaced in layers between the sedimentary rocks. The igneous rocks include basalt, which is a volcanic rock that was extruded onto the sediments as they were forming, and diabase, which was intruded into the buried sediments. The basalt and diabase are similar mineralogically, consisting primarily of pyroxene and plagioclase (Carswell 1976). Collectively, these sedimentary and igneous rocks are known as the Newark Supergroup (Lytle and Epstein 1987). The Newark Supergroup rocks generally strike to the northeast and dip approximately 10 to 15 degrees to the northwest.

The bedrock beneath the Site is the upper Triassic–lower Jurassic Passaic Formation (formerly known as the Brunswick Formation). The Passaic Formation consists of reddish-brown shale, siltstone, and sandstone. In the northeastern part of the Newark Basin, the Passaic Formation is approximately 9,000 ft thick (Lytle and Epstein 1987).

The unconsolidated surficial deposits that cover the bedrock in the region of the Site include material related to the glacial episodes of the Pleistocene Epoch, and alluvium deposited by present-day streams on the glacial material. The glacial units consist primarily of varved lake deposits deposited in glacial Lake Hackensack. The varves are thin (1/16 to 1/2 in.), alternating layers of clay- to sand-sized particles. Each pair of silt and clay layers represents one annual cycle of deposition (Bloom 1978). The varved deposits can be up to 300 ft thick. The glacial units also include till laid down during glacial advances and retreats (Carswell 1976).

The youngest units in the vicinity of the Site are thin, Holocene alluvial deposits, such as sand and gravel. In addition, the surficial geology of the Site includes a layer of estuarine and salt-marsh deposits consisting of organic silt and clay, and salt-marsh peat (Stanford 1993). This layer is considered a post-glacial deposit and is present in the Hackensack Valley (which includes the Site) at thicknesses as great as 20 ft but usually less than 10 ft (Stanford 1993). This layer is also termed “meadow mat.” In some areas, silt and fine-grained sand underlie the meadow mat (Carswell 1976).

Previous geotechnical studies of the Site (J.S. Ward 1974, 1975) indicate that the unconsolidated units at the Site are consistent with those described in the region. These units are also described in the BITM (Volume 4). Boring logs from Ward (1974, 1975) are included in Appendix P. With increasing depth, these units include the following.

- Surficial fill, in the undeveloped filled area, consisting of gravel, sand, silt, and clay, with shale fragments as well as glass, brick, cinders, porcelain, wire, leather, cloth, coal, chemical matter, wood, shingles, rubber, plastic, metal, and other debris. Based on detailed borehole logging during the Phase IA SFI in 2002, surficial fill in the developed area consists of predominantly silt and clay, with limited sand and gravel. The fill ranges in thickness from approximately 5–8 ft in the developed area of the Site to approximately 3–14 ft in the undeveloped filled area of the Site. Fill is not known to be present in the marsh area.

- Meadow mat, consisting of fibrous organic peat and silt, which, if present, ranges from 0.5 to 4 ft thick. The meadow mat is thinnest beneath the undeveloped area where artificial filling has occurred, which may indicate the meadow mat in this area has been compressed by the overlying fill. The meadow mat appears to have been removed in the vicinity of the U.S. Life and Wolf warehouses (likely as a result of construction of the warehouses) and is generally absent in the northwest portion of the undeveloped area adjacent to the warehouses.
- A 5- to 10-ft-thick layer of fine to medium-grained sand.
- A varved, gray to red-brown silt that is 62 to 146 ft thick.
- A red-brown silty sand unit that is at least 20 ft thick.

The most recent map on surficial geology in the region (Stanford 1993) includes a transect through the Ventron/Velsicol Site. Depth to bedrock is approximately 250 to 300 ft at the Site. According to the surficial geology map, the surface layer is artificial fill, followed by a layer of estuarine and salt-marsh deposits (consisting of organic silt and clay, and salt-marsh peat), and then a layer of varved silt and clay that extends to bedrock.

Geologic cross sections (Figures N-1 through N-8) and figures depicting the horizontal extent of organic-rich silt/peat and clay (Figures N-9 and N-10) were constructed using primarily test pit and borehole log data from the 1974 and 1975 Ward geotechnical investigation reports (Ward 1974, 1975) and borehole log data from the Phase IA SFI (Exponent 2003). Only limited information from the 1990 and 1991 NJDEP monitoring well logs (MW-1 through MW-12) was used due to the lack of detailed soil descriptions in these logs. These data were sufficient to correlate two significant soil features across the Site: the near-surface meadow mat and the top of the fine-grained deposits (undifferentiated silt and clay and varved clay as described by Ward).

Ward (1974) observed meadow mat generally throughout the (now) developed portion of the Site prior to construction of the warehouses. In contrast, a meadow mat layer was only observed in one of the Phase IA SFI boreholes (i.e., borehole B-8, located on the eastern side of the Wolf Warehouse adjacent to the undeveloped area). Therefore, meadow mat was assumed to have been removed in the vicinity of the U.S. Life and Wolf warehouses prior to construction and this layer is not included beneath the warehouses in Figure N-9. As-built drawings or grading plans, if any, of the building foundations were not available to Exponent for review. Removal of the meadow mat (although not recommended by Ward [1974]) is consistent with the Ward (1975) recommendation for a proposed (but never built) development on the undeveloped portion of the Site.

The meadow mat is absent from portions of the undeveloped area based on the 1975 Ward data. The meadow mat is distinctly identified in the Ward (1975) borehole logs for the undeveloped portion of the Site (described as organic silt or peat). Shaded areas where the meadow mat is absent in the undeveloped portion of the Site on Figure N-9

were delineated based on the absence of “organic silt” or “peat” descriptions in the borehole logs. There are instances where trace vegetation or roots were apparently observed (e.g., in B-1B and B-2B), but because these descriptions are substantially different from the specific reference to organic silt or peat in other logs, the presence of trace vegetation or roots was not interpreted as indicating the presence of meadow mat. For the single monitoring well (MW-14) in the shaded area of the undeveloped portion of the Site, meadow mat was reportedly not encountered during drilling based on the borehole log for this well.

Exponent’s use of the term “varved clay” was adopted from the Joseph S. Ward reports (Ward 1974 and 1975). Varved clay was not observed during the Phase IA SFI in 2002, but our observations are consistent with historical observations. In the developed portion of the Site, Ward used this nomenclature to describe, in general terms, not only varved clay and silt, but also clay and silt with layers of sand at the top of the varved clay unit. The clay/silt with layers of sand was sufficiently thick (greater than 10 ft thick) throughout the undeveloped area and in some portions of the developed area for Ward to differentiate it as a separate unit. In the 1974 Ward boreholes where it was not differentiated (e.g., boreholes B-1, B-3, U/D-1), the silt/clay with layers of sand was a minimum of 6 ft thick overlying varved clay. During the Phase IA SFI, the clay unit was penetrated 5 ft or less except for one borehole that penetrated the clay 8 ft (by contrast, clay was penetrated over 50 ft by Ward in the developed portion of the Site). The limited penetration depth and our observations were insufficient to identify it as one or the other unit, but this does not rule out the existence of varved clay.

The fine-grained units (i.e., clay/silt with layers of sand and varved clay) were not differentiated in the Phase IA SFI in 2002. The two fine-grained units are very similar (i.e., clay or silt with sand layers or seams) and were differentiated by Ward only by the presence or absence of a varved appearance. Both units likely exhibit similar physical or hydraulic properties and appear to be indistinguishable from a hydrogeologic perspective. Therefore, the fine-grained units will be considered undifferentiated (i.e., described only as fine-grained deposits) for the purposes of this report.

Examination of the geologic cross sections (Figures N-1 through N-8) indicates that the top of the fine-grained deposits forms a slightly sloping to channeled surface occurring at depths of approximately 7–26 ft bgs within the Site boundary. In the developed area, the top of the fine-grained deposits exhibits a channeled surface (filled predominantly with overlying sand) with the greatest depth to the deposits observed beneath and northeast of the Wolf Warehouse.

3.4 Surface and Subsurface Soils

3.4.1 Developed Area

The Wolf and U.S. Life warehouses occupy much of the developed area of the Site. The remainder of the developed area of the Site is covered with asphalt pavement, or at the rear of the warehouses, covered with gravel, which forms the bed for the railroad tracks in this area. There is no exposed soil in the developed area, except in the ditch along a portion of the southwest side of the railroad tracks behind the Wolf warehouse.

Ward (1974) reported a 2- to 3-ft-thick layer of fill consisting of clayey granular material with shale fragments underlain by a 6- to 12-in.-thick layer of black organic silt with roots that, in turn, was underlain by generally fine to medium sand. This report also recommended placement of clean granular fill to raise the grade prior to building the warehouses. Boring logs of wells MW-8, MW-9, MW-10, and MW-11, which were installed in the developed area by the NJDEP in 1990, indicated that white, gray, and black sand and gray and black clay were present in this area to depths of 16 ft bgs; however, the logs lack sufficient detail to allow meaningful interpretation. Based on detailed borehole logging during the Phase IA SFI in 2002, surficial fill in the developed area consists of predominantly silt and clay, with limited sand and gravel. The fill ranges in thickness from approximately 5–8 ft in the developed area of the Site. Based on these data, it appears that regrading and fill placement in the developed area occurred prior to construction of the existing warehouses, including removal of a majority of the meadow mat.

The undeveloped filled area was further investigated during the cutoff wall investigation described in Section 2.11. Based on the records review, the most likely cutoff wall locations were identified as Alternative 2 and Alternative 3 in a report by J.S. Ward (1975), as shown in Figure 2-2.

The containment wall was further investigated through subsurface investigation using a backhoe, as described in Section 2.11. At location 1, an area of approximately 25 ft long and 15 ft wide was excavated to a depth of at least 3 ft. No evidence of a containment wall was encountered at location 1. At locations 2 and 3, evidence of a concrete wall from approximately 1 to 3.5 ft bgs was uncovered. The width of the wall was not investigated to avoid excessive disruption to the asphalt surface. However, the wall was consistently wider at the top than at depth. Excavation continued at location 5 and 4, respectively. Evidence of the containment wall was not found at either location.

3.4.2 Undeveloped Filled Area

The entire undeveloped filled area was previously marsh. The area was filled and vegetated long enough to allow development of some near surface soil. Shallow soil in the undeveloped filled area generally consists of brown sand and silt, with some organic

material such as roots. Small amounts of gravel and clay are also present in some locations. Additionally, surficial fill materials such as those listed in Section 3.3 are found throughout the area. Boring logs of wells MW-1 through MW-7, and MW-12, which were installed in the filled area by the NJDEP in 1990, indicated that subsurface soil consisted of a mix of sand, silt, and clay to depths of 20 ft bgs. Other materials, including wood and “trash,” were also observed at these locations. Copies of NJDEP well installation logs are provided in Appendix K.

Additional information regarding the variety of surficial fill materials was obtained during the test-pit excavations (Section 2.2.2). A summary of fill materials encountered is listed below, and more complete descriptions can be found in the test-pit logs (Appendix D).

- Drums: large and small metal and fiberboard drums, both empty and filled with a variety of substances (paint-, resin-, crystalline-like materials)
- Glass: bottles, beads, and large quantities of other broken glass
- Plastic: sheeting, film, cabling, rods, and bottles
- Rubber: tires and rubber hoses
- Metal: pipes, appliances, automobile parts, and scrap metal
- Calcium sulfate sludge
- Construction debris: plywood, tar paper, shingles, brick, tiles, cement slabs, and cinder blocks
- Other miscellaneous items: toilet, sink, washing machine, refrigerator, paper products, cardboard, rolls of colored foil, rags, wood, wood chips, and sludge.

3.4.3 Marsh Area

Shallow soil in the marsh area consists of black to brown silt and roots. Filling is not known to have occurred in the marsh area. During sample collection, the soil at most locations was saturated within the 0–2 ft bgs sampling interval. The depth of saturation observed during soil sample collection was likely related to the tidal cycle. Sampling within the marsh area generally occurred from low to mid-tide.

3.5 Surface Water Hydrology

3.5.1 Surface Water Drainage Network

Surface water drainage at the Site is generally to the southeast, where Berry's Creek borders the Site. The three ditches that drain the southern (marsh) part of the Site are described below (see Figure 1-2). The marsh portion of the Site reportedly floods to a depth of up to 2 ft during high tide (J.S. Ward 1975). Field staff for this remedial investigation observed that, as the flood tide drains this area, the bulk of the water flows through a channel along the eastern edge of the marsh to Nevertouch Creek, before converging with Berry's Creek. The flow of water is diverted back to the Berry's Creek channel during low tide. There are no well-defined drainage patterns for the undeveloped filled area. The developed area is paved, and drainage generally is directed toward the drainage ditch between the warehouses. Drainage from this area flows along the western property boundary (in the West Ditch) toward the Diamond Shamrock/Henkel Ditch (north).

The Diamond Shamrock/Henkel Ditch (north), which marks the boundary between the undeveloped filled portion of the Site and the marsh portion, flows in a southeasterly direction into Berry's Creek. The Diamond Shamrock/Henkel Ditch (south) is coincident with the Site's southwestern property boundary and converges with Nevertouch Creek, which then forms the southern Site boundary up to its confluence with Berry's Creek. A drainage ditch is roughly halfway between the two ditches. The Diamond Shamrock/Henkel Ditch (south) is an open drainage channel that is fed by Nevertouch Creek and Berry's Creek. Prior to 1997, the south ditch provided the former Henkel plant production pond with non-contact cooling water. After use, the cooling water, together with storm water from the facility, would drain into the Diamond Shamrock/Henkel Ditch (north) before discharging to Berry's Creek (IT 1988).

Berry's Creek flows generally south from the Site in a 4-mile course through tidal marshes before joining the Hackensack River. Much of the stream course is curving. The stream flow in the last 1.25 miles of this creek has been diverted to a straight, man-made channel known as Berry's Creek Canal. The overall drainage pattern of the Hackensack Meadowlands is anastomotic (meandering and braided), which is common in tidal marshes (Bloom 1978). The Hackensack River then flows southward into Newark Bay.

3.5.2 Surface Water Elevation and Tidal Action

The tide gate, adjacent to the Site, divides Berry's Creek into an upstream and a downstream reach. Surface –water level measurements made during the hydrogeological tidal study, January 14–16, 1998, are shown in Figure 3-1. The surface water elevation fluctuates tidally, with a mean elevation only slightly higher than mean sea level. The surface water elevation at low tide is approximately the same upstream and downstream

of the tide gate. The tidal range in the upstream reach is approximately 2 ft, while in the downstream reach, the tidal range is approximately 6ft. Therefore, at high tide, the surface water elevation downstream of the tide gate is approximately 4ft above that in the upstream reach. Surface water elevations in the upstream reach vary depending on the tide gate configuration and the amount of debris caught in the gate.

The surface water elevation on the downstream side of the tide gate was measured and recorded for a weeklong period from October 24 through October 31, 1997 (during a neap tide). These observations indicated a tidal range of approximately 7ft, 1 ft greater than measured during the hydrogeological tidal study. Surface water elevations are discussed further in Section 3.6.2.1.

The tidal range of Berry's Creek has been reported in several other studies as ranging between 5.5 and 6 ft (ERM 1985). These measurements were made 1.8 miles downstream of the Site. The mean tidal range where Berry's Creek Canal joins the Hackensack River is approximately 4.5ft (HMDC 1982).

3.5.3 Frequency and Extent of Flooding

Figure 2-9 of the BITM (Volume 4) shows a map of the 10-year and 100-year flood zone areas, while Figure 3-2 shows a map of the 100-year and 500-year flood zone areas. The area of the 500-year flood zone is only slightly larger than the area encompassed by the 100-year flood zone. The entire marsh area and much of the developed area of the Site are within the 10-year flood zone. Portions of the marsh area are flooded twice a day, during the high tide. A larger portion of the marsh area is flooded during higher tide events, such as spring tides and storms.

3.6 Groundwater Hydrogeology

3.6.1 Regional Hydrogeology

Groundwater occurs in a network of joints and fractures in the Passaic Formation. The consolidated rock between the joints and fractures generally does not contain significant amounts of groundwater, although sandstone beds commonly have moderate intergranular porosity. The joints and fractures are typically found within fissile mudstones and siltstones and are parallel to bedding (which strikes northeast and dips 10 to 15 degrees to the northwest), forming tabular aquifers that are separated by massive layers that act as aquitards. Other major joint systems are perpendicular to bedding and strike northeast. The net result is that groundwater flow in the Passaic Formation is predominantly in the direction of strike (Houghton 1990). Fresh groundwater in the Passaic Formation in the Hackensack River Basin is generally limited to depths of less than 200 ft bgs (Carswell 1976).

Groundwater also occurs in the pores of the unconsolidated units that overlie the Passaic Formation. However, much of the unconsolidated materials, such as the varved silts and clays, and glacial tills, have low permeability and are not significant sources of groundwater. Unconsolidated sands and gravels have greater permeability, but these units are generally thin and areally restricted, so the amounts of groundwater produced are not significant (Carswell 1976).

Groundwater is recharged principally through infiltration of precipitation in the topographically higher portions of the groundwater basin. Deeper groundwater discharges directly to the ocean, while shallower groundwater generally discharges to the surface water bodies in the area, such as Berry's Creek and the Hackensack River.

3.6.2 Site Hydrogeology

The investigation of Site hydrogeology included a tidal study to determine the degree of tidal influence on groundwater elevations, three rounds of synoptic groundwater level measurements during Phase I and six rounds during Phase IA, and hydraulic conductivity tests. These three studies are described below.

3.6.2.1 Hydrogeologic Tidal Study

The tidal study included periodic water level measurements at six onsite wells and at two locations in Berry's Creek (one upstream and one downstream of the tide gate) for approximately 48 hours on January 15 and 16, 1998. Light rain and snow fell intermittently during the tidal study, beginning 20 hours after the study began and ending 18 hours later. The amount of precipitation measured in an onsite rain gauge during this period was 0.07 ft.

Figure 3-1 is a hydrograph that illustrates the results of the tidal study. Water-level variations in each monitoring well over the duration of the tidal study are shown as solid lines. Water-level variations in Berry's Creek appear as solid ovals, because measurements were made by hand at less frequent intervals than the measurements made by the electronic data loggers in the monitoring wells. Each dot represents one water level measurement in Berry's Creek. The predicted tidal elevations for periods when measurements were not made are shown as open ovals.

As shown in Figure 3-1, the water surface elevation fluctuates above and below msl in accordance with tidal fluctuations. Tidal driven surface water elevation fluctuations are significantly attenuated upstream of the tide gate. The water elevation on both sides of the tide gate at low tide was approximately 3 ft below msl. Surface water elevations downstream of the tide gate rose sharply as high tide came in, but the tide gate prevented an increase of similar magnitude upstream of the gate. The tidal elevation variation in

Berry's Creek was approximately 6 ft downstream of the tide gate, and 2 ft upstream of the tide gate.

Water levels in Berry's Creek upstream and downstream of the tide gate were lower than groundwater levels in all the monitoring wells included in the tidal study, except as noted below.

- At high tide, the water level in Berry's Creek downstream of the tide gate is higher than the water level in well MW-6. MW-6, however, is located approximately 280 ft north (upstream with respect to Berry's Creek) of the tide gate and showed no response to tidal fluctuations. Therefore, it is unlikely that the water level in Berry's Creek downstream of the tide gate would influence the water table in the vicinity of MW-6.
- During high tide on January 16, 1998, the surface water level in Berry's Creek downstream of the tide gate was slightly (approximately 0.2 ft) higher than the groundwater level in monitoring well MW-4. The groundwater level in MW-4 did not fluctuate in response to the tide.

This relationship between the groundwater and surface water surface elevations indicates that groundwater from the Site discharges toward Berry's Creek during the entire tidal cycle. There is, of course, likely to be bank storage of infiltrating surface water between the Creek and the well locations. In this fringe close to the Creek banks, flow direction may vary over the tidal cycle.

Groundwater elevations in five of the six wells (MW-1, MW-2, MW-4, MW-6, and MW-7) included in the tidal study did not show any variation that coincided with the tides in Berry's Creek. The only well that exhibited any tidal fluctuation was MW-12. The range of water-level elevations in this well was less than 0.5 ft, suggesting a small, but measurable, influence by tides in the Diamond Shamrock/Henkel Ditch (north) on groundwater in the area of MW-12.

Although the water level in MW-12 fluctuated, the groundwater elevation in this well did not change enough to alter the direction of the gradient relative to the other wells monitored during the tidal study (excluding the latter part of the test, when the water level in MW-12 may have been influenced by precipitation). Specifically, the tidally-induced water level changes in MW-12 did not cause the water level in MW-12 to rise above or fall below the levels in any of the other monitored wells.

Water levels in wells MW-7, MW-12, and Berry's Creek increased slightly during the latter part of the test. This may be related to the precipitation that occurred during the monitoring period.

The lack of significant changes in groundwater elevation during the tidal study indicates that the groundwater flow direction at the location of the perimeter monitoring wells is not influenced by the tides in Berry's Creek. As mentioned above, there is likely to be tidal influence on groundwater elevations between the perimeter wells and the adjacent tidal water bodies. Uptake of the tidal front in the unsaturated zone (bank storage), however, apparently absorbs that influence between the creek or ditch banks and the well locations. Therefore, groundwater elevation measurements at the existing wells made at any time during the tidal cycle should provide an adequate representation of the groundwater flow direction at the Site, with recognition that the flow direction may fluctuate as driven by tidally-induced surface water elevation changes in the perimeter area between the wells and the creek bank.

3.6.2.2 Site-Wide Groundwater Flow Patterns

Water levels were measured in the 12 wells installed by NJDEP on October 15, 1997, December 9, 1997, and January 15, 1998, during the Phase I investigation. Water levels were measured in all 15 monitoring wells on December 10, 1999, February 10, 2000, April 10, 2000, June 19, 2000, and September 24, 2002, during the Phase IA investigation. These data are tabulated in Table 3-1 and illustrated in Figures 3-3a through 3-3c. Figures 3-3a and 3-3b show the temporal water level elevation changes for each of the monitored wells, while Figure 3-3c shows the range of variation over time for each of the monitored wells. Groundwater elevation information for the period during NJDEP sampling (1990-1991) could not be located. The following discussion on groundwater surface elevations and flow patterns is derived from information obtained during the Phases I and IA investigations.

Figures 3-3a and 3-3b show that groundwater levels were generally rising during the period October 1997 through January 1998, but have been relatively stable, at levels similar to the January 1998 levels, from December 1999 through June 2000. The exception to this general trend is the water level in MW-9, which has risen more than in other wells and has continued rising throughout the monitoring period, except in the June 2000 measurement when it declined 0.06 ft from the prior measurement. One reason for this rise in MW-9 water level could be increased infiltration from the ditch between the two warehouses, perhaps caused by increasing blockage of the drainage pipe at the downstream end of the ditch, resulting in increasing surface water levels. The relationship between the water surface elevations in MW-9 and MW-7 is particularly significant with regard to groundwater flow patterns. When the water level is higher in MW-7 than in MW-9, flow in the vicinity of these two wells is generally toward the developed area from the undeveloped area. The water level in MW-7 is higher than in MW-9 for each round of measurements except on April 10, 2000, when the water level in MW-9 was essentially the same (0.04 ft higher) as in MW-7.

Second, Figure 3-3c shows that the water level variations in the wells around the perimeter of the Site adjacent to surface water bodies are much smaller than in the wells

further from the surface water. This pattern is expected due to the influence of the surface water bodies, which act as boundary conditions for the groundwater.

Figures 3-4a, b, c, and d show groundwater contours developed using the water-level data collected on December 9, 1997, December 10, 1999, April 10, 2000, and September 24, 2002. These four data sets were selected as representative examples of the groundwater surface elevation measurements during Phases I and IA. The December 9, 1997, data set is the most complete set of Phase I measurements and the April 10, 2000, dataset is the one dataset in which the water surface elevation in MW-9 was higher than in MW-7.

Major features of the Site-wide groundwater flow patterns include:

- A generally radial flow pattern (outward from the center) is apparent in the undeveloped filled area, with the highest groundwater levels in monitoring wells MW-2 and MW-3. This is most likely caused by higher infiltration of water in the undeveloped filled area than in the areas to the north and west of the undeveloped area.
- Along with the radial flow patterns, there is likely to be a small downward vertical component of flow generally in the center of the undeveloped filled area, which then transitions to a small upward vertical flow component near the perimeter of the undeveloped filled area.
- As part of the overall radial flow patterns, groundwater in the eastern and southern portions of the undeveloped filled area flows toward Berry's Creek and the Diamond Shamrock/Henkel Ditch (north).
- Groundwater in the developed area flows generally north to south under the U.S. Life Warehouse and then likely turns to the west-southwest as it meets the radial flow from the undeveloped filled area.
- The combination of the radial flow pattern in the undeveloped filled area and regional flow from the north appears to create a zone with low groundwater gradients in the vicinity of the Wolf warehouse. Details of the flow patterns in the region are likely to be very sensitive to the groundwater surface elevation in MW-9, which has fluctuated substantially during the monitoring period for this study. The data indicate, however, the flow direction is consistently from the undeveloped area toward the developed area in the vicinity of the Wolf warehouse.

The groundwater hydraulic gradients appear to be relatively shallow through much of the undeveloped area (e.g., inside the 3-ft contour) and under the Wolf warehouse (as mentioned above). Along the Diamond Shamrock/Henkel Ditch (north) and Berry's Creek as far upstream as the tide gate, the gradients close to the ditch/creek banks appear to be relatively steep. Along Berry's Creek upstream of the tide gate, however, the

gradients appear to be much shallower. This change in gradient may be due to the influence of the tide gate on the mean water surface elevation in Berry's Creek, and the subsequent influence of the surface water elevation on the groundwater surface elevation near the Creek. Based on measurements during the tidal study (see Section 3.6.2.1), the mean water surface in Berry's Creek upstream of the tide gate is about 2 ft lower than downstream of the tide gate. The water surface elevation in MW-6, which is set back from Berry's Creek about the same distance as wells MW-1, MW-3, MW-4, and MW-12, is about 2 ft lower than in these other four wells. The water surface elevation in MW-5, which is just slightly upstream of the tide gate, is between the elevation in MW-6 and in the four other wells listed above.

Evidence for the existence of a concrete containment wall adjacent to the Wolf Warehouse (see Section 3.4.1) was inconclusive. The presence of a concrete wall to a depth of 3.5 ft bgs at two locations is expected to have minimal effect on groundwater movement in the vicinity of the warehouse. Depth of groundwater in this area (monitoring well locations MW-7 and MW-8) varied between 3.66 and 6.68 ft during the remedial investigation (Table 3-1).

3.6.2.3 Hydraulic Conductivity

Hydraulic conductivity was determined at each of the 12 Phase I monitoring wells using slug tests. Table 3-2 provides a summary of the results. The Aqtesolv[®] graphs showing the time vs. displacement field data are provided in Appendix E.

As shown in Table 3-2, the hydraulic conductivity values ranged from 1.6×10^{-4} ft/min at well MW-6 to 6.6×10^{-2} ft/min at well MW-4, a range of more than two orders of magnitude. The greatest variability in hydraulic conductivity was measured in wells located in the undeveloped filled area. This wide range of hydraulic conductivity values is most likely due to the heterogeneity in the fill materials in which the wells are screened. Well logs indicate that monitoring wells MW-1, MW-2, MW-4, and MW-6 all contain fill below the water level observed in these wells. Based on the Site history, observations during the test pit program, and their location, wells MW-3, MW-5, MW-7, and MW-12 may also be installed in fill materials (although fill was not reported in the NJDEP well installation logs [Appendix K]).

The wells in the developed area, including wells MW-8, MW-9, MW-10, and MW-11, exhibited a relatively narrow range of hydraulic conductivity values, from 1.8×10^{-3} to 9.1×10^{-3} ft/min. Based on the NJDEP well installation logs (Appendix K), these wells are screened in native sands and clays; fill was not observed during installation of these wells. This range of hydraulic conductivity values is typical of silty sand (Freeze and Cherry 1979).

3.6.3 Groundwater Classification

As described in the BITM (Volume 4), the aquifer beneath the Site has been designated as a Class II-A aquifer, in accordance with the New Jersey GWQS (N.J.A.C. 7:9-6). The primary designated uses for Class II-A groundwater are potable water and conversion to potable water through conventional water supply treatment, mixing, or similar techniques.

3.7 Ecological Description

3.7.1 Vegetation Cover Types

The description of vegetation cover types in this section reflects conditions observed during two Site characterizations conducted on May 22, 1997, and May 7, 1998. During the 1997 Site characterization, the focus was on identifying vegetation structure and hydrology for evaluating potential wetland conditions. During the 1998 Site characterization, the focus was on evaluating the habitat structure and quality provided by vegetation cover types, and on documenting the presence of resident and/or transient wildlife.

3.7.1.1 Wetlands

Wetlands were delineated during the 1997 field season (see Sections 2.6 and 3.7.4.1). The wetland delineation report was prepared and submitted as a separate document (see Shisler 1997). No rare, threatened, or endangered plant species have been identified or are expected to occur at the Site (Shisler 1997).

3.7.1.2 Upland Vegetation

Table 3-3 is a list of the plant species observed during the 1998 Site characterization. In general, upland vegetation covers the undeveloped filled portion of the Site. Plant species present are primarily non-native opportunistic trees and shrubs and herbaceous plants that are characteristic of urban regions. These species are expected based on the disturbed nature of the property and its location in an industrial area.

Vegetation categories in the undeveloped filled area can be distinguished based on structure. Three zones are commonly used in describing upland vegetation: canopy, understory, and groundcover. Each zone refers to the vertical “position” of vegetative species within the terrestrial environment. Canopy species include larger, more developed trees like oak and maple. Understory (i.e., below canopy) species include woody shrubs, saplings, and brush like sumac or knotweed. Groundcover, as its name

implies, refers to creeping, sometimes rhizomatous, perennial species of herbs and grasses that cover the ground.

Figure 3-5 illustrates the approximate distribution of canopy species at the Site. As indicated in the figure, portions of the Site (mainly in the northernmost area) have an open canopy of trees, consisting in part of tree-of-heaven (*Ailanthus altissima*), black locust (*Robinia pseudo-acacia*), poplar (*Populus tremuloides*), cottonwood (*Populus deltoides*), mulberry (*Morus* sp.), choke cherry (*Prunus virginiana*), red maple (*Acer rubrum*), and sweet gum (*Liquidambar styraciflua*). Older and larger trees reach estimated heights exceeding 75 ft. Other portions of the Site (to the south and west) show smaller, more fragmented stands of canopy that comprises a similar mix of species. Shisler (1997) presents a more complete list of plants observed at the Site.

Figure 3-6 represents the distribution of understory species at the Site. The distribution of understory species, though somewhat fragmented, is mostly along the perimeter of the Site. This is particularly true for eastern, western, and southern portions of the undeveloped filled area. One reason for this distribution pattern is that a key species of the understory, the common reed (*Phragmites australis*), is associated with the low-lying disturbed areas that border Berry's Creek and the Diamond Shamrock/Henkel Ditch (north).

Figure 3-7 shows the approximate distribution of common reed at the Site. Note that the distribution as shown in Figure 3-7 is similar to that in Figure 3-6, indicating that common reed is the dominant understory species.

Other vegetation beneath the tree canopy includes sumac (*Rhus copallinum*), wild rose (*Rosa multiflora*), knotweed (*Polygonum cuspidatum*), and saplings of hardwood species. A thick layer of herbaceous weeds—primarily mugwort (*Artemisia vulgaris*)—is present as groundcover throughout most of the undeveloped filled area of the Site.

Photographs in Figure 2-10 of the BITM (Volume 4), taken in May 1997, illustrate vegetation on the undeveloped filled portion of the Site. BITM Figure 2-10, Photograph A, shows a canopy of relatively small tree-of-heaven with a weedy herbaceous layer. This photograph was taken in the northeastern quadrant of the undeveloped filled area of the Site. BITM Figure 2-10, Photograph B, taken close to Photograph A, shows an area without a canopy of trees, with dense early-season growth of annuals, including common reed.

3.7.2 Wildlife

The ecological isolation and disturbed nature of the Site affects its wildlife resources. Primary local land uses are industrial, and a substantial transportation infrastructure is present (a railroad bed adjoins the Site, and municipal roadways and a state highway are present within a few hundred yards). As shown in the aerial photograph review (Section 2.4 of the BITM, Volume 4), the Site was significantly disturbed through filling,

re-grading, vehicular traffic, ditch construction, and material disposal from 1940 through 1974. Common urban species of mammals (e.g., woodchuck [*Marmota monax*], Norway rat [*Rattus norvegicus*], opossum [*Didelphis virginiana*], cottontail rabbit [*Sylvilagus floridanus*], and muskrat [*Ondatra zibethicus*]) present at the Site are listed in Table 3-4.

Resident birds that are characteristic of human-influenced landscapes were commonly observed at the Site. Species observed included red-winged blackbird (*Agelaius phoeniceus*), robin (*Turdus migratorius*), common grackle (*Quiscalus quiscula*), starling (*Sturnus vulgaris*), English sparrow (*Passer domesticus*), mourning dove (*Zenaidura macroura*), mockingbird (*Mimus polyglottos*), catbird (*Dumetella carolinensis*), blue jay (*Cyanocitta cristata*), and others (as listed in Table 3-4). Migratory species, including a number of warblers (Parulidae) and flycatchers (Tyrannidae), were observed onsite in the spring of 1997. Under baseline conditions, individual migrants likely are present for a few days to weeks in the spring and autumn. Other birds that are characteristic of the Hackensack Meadowlands as a whole may be present as transients. Herons, egrets, hawks, sandpipers, and plovers may be expected to forage in the Site vicinity, although nearby human activity and lack of onsite habitat for these species probably restricts foraging.

Aquatic life has not been sampled but schools of killifish (*Fundulus*) have been observed in Berry's Creek. Other species of fish associated with estuarine creeks in New Jersey are also likely to at least be periodically present. Regionally common species include herrings, catfish, silversides, eels, temperate basses (*Morone*), sunfish, minnows, bluefish, and weakfish. The assemblage of aquatic macroinvertebrates is likely to include such taxonomic groups as Gastropoda (snails), Bivalvia (clams and mussels), Oligochaeta (worms and leeches), Polychaeta (bristle worms), Crustacea (crabs and shrimp), and Insecta (insects).

Lists of endangered, threatened, rare, or uncommon species for the Site vicinity, from the New Jersey Natural Heritage Database for Bergen County (March 1997), have been reviewed. These lists will be included with the ecological risk assessment report (to be submitted as a separate document). In general, species on these lists could be present on the Site where suitable habitat exists. No endangered, threatened, rare, or uncommon animal species were observed during the field reconnaissance visits to the Site. No wildlife management areas have been identified in the immediate vicinity of the Site. This information will be confirmed in the problem formulation phase of the ecological risk assessment and through consultation with the Hackensack Meadowlands Commission (HMC) and New Jersey Natural Heritage Program personnel.

3.7.3 Habitat Quality and Resource Value to Biological Communities

Habitat quality is related to an ecosystem's structural integrity and the attributes that support biological communities. At the Site, habitat quality is compromised by several physical factors. Ecological isolation of the Site (due to surrounding industrial and commercial land use) prevents recruitment of species and impairs diversity.

Furthermore, the long history of physical disturbances has created conditions favorable for opportunistic vegetation that is characteristic of waste areas (e.g., tree-of-heaven, knotweed, and common reed). These physical factors have resulted in fragmented or impaired conditions that reduce habitat quality by preventing wildlife from establishing territories for nesting and foraging.

For purposes of the following discussion, the developed portion of the Site (approximately 7 acres of predominantly buildings and paved areas) and the undeveloped filled portion of the Site (approximately 19 acres) are considered to be the areas of habitat that may support terrestrial plant and wildlife communities. Small portions of this 26-acre area are jurisdictional wetlands. The remaining 12 acres of the Site (OU2) is predominantly marsh. Numerous species of wildlife associated with the Hackensack Meadowlands and Berry's Creek system may use this marsh as habitat for foraging and cover. Aquatic species utilize Berry's Creek and several small tidal ditches.

3.7.3.1 Terrestrial Habitats and Biological Communities

The value of habitat to terrestrial communities can be evaluated by examining the direct use of its resources by individual organisms. Habitats with high resource value support "healthy" biological populations, whereas habitats with low resource value support less desirable species. One method for evaluating resource value is to examine the resource type (in this case, onsite terrestrial vegetation), along with the functional feeding habits of observed wildlife species. In Tables 3-5 and 3-6, seasonal diets of birds and mammals observed at the Site are compared to the type and abundance of plant species that make up some proportion of their diet (Martin et al. 1961).

This comparison illustrates several important factors. For most species of birds observed at the Site, the percent of plant material as part of the diet varies considerably within and among species (Table 3-5). Rarely do birds consistently eat plant matter throughout all of the seasons. Two species, the mourning dove and the English sparrow, have diets that are consistently 90 percent (or greater) plant matter throughout the year. However, examination of the plant types that these species are known to consume, only knotweed is present at the Site, and only at low to medium densities. Moreover, both the English sparrow and the mourning dove have been shown to consume knotweed at proportions equal to only 2 to 5 percent of their vegetative diets (Martin et al. 1961). Red-winged blackbirds and marsh wrens could establish territories and nest in riparian areas, including areas heavily colonized by common reed. Both these species feed predominantly on insects, especially those associated with aquatic habitats.

Other species, such as the robin, consume a lower percentage of plant material throughout the year than do the English sparrow and mourning dove. However, the robin is more likely to utilize a wider range of Site resources, as documented by the greater number of plant species that are available as food (Table 3-5). This means that the robin is more likely to benefit from the resources at the Site, even though these plant species are present in relatively low abundance. It is important to recognize that robins, and

other birds observed at the Site, are likely to use offsite foraging areas to supplement their dietary needs.

For mammals, similar patterns of resource value at the Site emerge. For example, woodchucks and cottontail rabbits are considered to forage throughout the year almost exclusively on plant matter (Table 3-6). Furthermore, herbaceous plants are their primary source of food and are abundant at the Site. Although a specific estimate is not available as to the percent of herbaceous plant consumption in their diet, it is reasonable to assume that this value is high. Combined, these factors suggest that the cottontail rabbit and woodchuck could be supported by Site habitat. Field observations on the presence and relative abundance of these animals indicate that this is a reasonable conclusion.

One other mammal present at the Site that is important to consider is the muskrat. Similar to woodchucks and cottontail rabbits, the muskrat's diet throughout the year is composed primarily of plant matter. However, the plant species that are commonly consumed by muskrat (e.g., cattail, common reed, pondweed, and arrowhead) are distributed more along the south and east perimeter of the Site where aquatic habitat is present (Figure 3-5). Moreover, the foraging range of muskrats has been documented to be between 5 and 10 m of their semi-aquatic houses (U.S. EPA 1993). These factors suggest that the muskrat is not likely to utilize terrestrial resources at the Site.

3.7.3.2 Marsh and Open Water Habitats and Biological Communities

Marsh habitats provide refuge and forage for a variety of fish and wildlife species. However, the aquatic habitat associated with the Site has been subject to degradation due to human activities in the past. These impacts include the installation of the tide gate, construction of bulkheads, dredging for docks, filling for industrial buildings, ditching and draining of marshes, and land clearing. These anthropogenic impacts to the aquatic ecosystem have reduced habitat and plant diversity and, hence, reduced overall carrying capacity of the system. For example submerged aquatic vegetation is uncommon but large monoculture stands of common reed are very abundant.

There are several small inlets (ditches) in the marsh portion of the Site that enhance tidal exchange from Berry's Creek to the marsh area (OU2). These ditches may provide habitat for a number of aquatic organisms, including larval and nymphal stages of aquatic insects, shellfish, crustaceans, and smaller species of forage fish (possibly killifish [*Fundulus*] and silversides [*Menidia* spp.]). Larval aquatic insects would be in direct contact with sediments of these ditches thereby providing a potential pathway of exposure as a food source for other benthic macroinvertebrates, fish, birds, and other wildlife. Furthermore, emergence of aquatic insects into the marsh system may provide a food source for insectivorous birds, including some of the more common species that are likely to inhabit the marsh (e.g. marsh wrens [*Cistothorus palustris*] and red-winged blackbirds [*Agelaius phoeniceus*]). Thus, aquatic insects and other benthic macroinvertebrates associated with these ditches may provide a route of exposure to residential bird populations that use the Hackensack and Berry's Creek System. In

addition, should the small ditches support forage fish and other benthic macroinvertebrates, then wading (piscivorous) birds including the common egret (*Casmerodius albus*), the snowy egret (*Egretta thula*), the green heron (*Butorides striatus*), and the great blue heron (*Ardea herodias*) could be present.

Marsh habitats provide potential habitat for a variety of birds that are common in fresh- and brackish water wetlands. Insectivorous species that are common in marsh habitats include the marsh wren and red-winged blackbird. Several species of wading birds, including the common egret (*Casmerodius albus*), the snowy egret (*Egretta thula*), and the great blue heron (*Ardea herodias*), although not observed at the Site during past surveys, may also utilize portions of the marsh in the event that substrate and food supply are readily accessible.

Adjacent to the marsh are aquatic habitats consisting primarily of open water. The major open water habitats are Berry's Creek, a tidal creek tributary to the Hackensack River; Nevertouch Creek, a tributary to Berry's Creek; and the Diamond Shamrock/Henkel Ditches, tributaries to Berry's Creek and Nevertouch Creek. Fish and invertebrates are present in both watercourses as are aquatic mammals and birds such as muskrat and green heron. The physical features of both the creek and ditch have been modified by anthropogenic factors. Therefore habitat conditions are degraded.

3.7.4 Wetlands Functional Assessment

During 1986 and 1987, EPA, HMDC, ACOE, and NJDEP jointly conducted a wetlands functional assessment of the Hackensack Meadowlands District (HMD). One hundred forty-seven (147) wetland areas were evaluated for wetland functions. This interagency functional assessment was performed using a modified version of the ACOE functional assessment methodology known as the Wetland Evaluation Technique (WET). Wetland functions included in WET are: groundwater recharge and discharge, flood flow alteration, sediment stabilization, sediment/toxicant retention, nutrient removal/transformation, production export, aquatic diversity/abundance, general fish habitat, general wildlife habitat, general waterfowl habitat, wildlife diversity/abundance, and waterfowl functions (Adamus et al. 1987).

The WET methodology as modified by the interagency team was designated the Indicator Value Assessment (IVA) method (U.S. EPA and ACOE 1995). The IVA is an indexing system developed specifically for the HMD that used chemical, physical, and biological wetland functional indicators to assess wetland conditions. The IVA provided a "semi-quantitative" measure of wetland functional indicators and utilized historic data presented in the Advanced Identification of Wetlands, previously conducted in the HMD (U.S. EPA 1992a).

Data collected during the interagency IVA were also used by the agencies to prepare a Draft Environmental Impact Statement (DEIS) for the HMD Special Area Management Plan. The DEIS used an indexing method for the three major wetland attributes; Water

Quality, Wildlife Habitat, and Social Significance. The indexing system grouped relevant attributes to a single heading. These attributes were then scored. The scores attached to these attributes do not reflect the size of the wetlands but rather represent a kind of “value per acre,” which allows comparison of the wetland attributes among different wetlands.

The interagency team using the IVA methodology divided the study area into 147 assessment areas (AA). AA 4B was a wetland area of Upper Berry’s Creek that consisted of 37.69 acres, adjacent to and including a portion of the Site. Therefore, the interagency report (U.S. EPA and ACOE 1995) describing the findings of the IVA of AA 4B and WET were reviewed and used as background and basis for the Site-specific functional assessment. Approximately 16 acres of jurisdictional wetlands exist on the Site, of which 12 acres is the tidal marsh associated with Berry’s Creek and OU2 (see Section 3.7.4.1).

The site-specific wetland functional value was also assessed by a regional wetland expert, Joseph K. Shisler, Ph.D., during May 1997. Dr. Shisler utilized his Best Professional Judgment (BPJ) for evaluating wetland functions. He also delineated the wetlands.

The following three subsections discuss the wetland delineation, IVA regional functional assessment in the vicinity of the Site and the subsequent DEIS wetlands functional ratings, and the site-specific BPJ assessment performed by Dr. Shisler.

3.7.4.1 Wetlands Delineation

A wetland delineation of the Site was conducted by Joseph K. Shisler, Ph.D. on May 22, 1997, and documented in his report dated November 20, 1997 (Shisler 1997). The wetland delineation was verified by the New York District of the ACOE on June 22, 1998 and documented in a letter from ACOE dated December 3, 1998. The verification by the ACOE is referred to as a “jurisdictional determination (JD).”

Based on the delineation and JD there are 15.77 acres of tidal wetlands in the southern section of the Site that consist of a dense monoculture of common reed (*Phragmites australis*) and 0.34 acres of nontidal wetlands upstream of the tide gate and in two isolated areas on Site. The tidal wetlands include the marsh area, bank areas adjacent to Berry’s and Nevertouch Creeks downstream of the tide gate, and two tributary ditches (the Diamond Shamrock/Henkel Ditches) present along the north and south sides of the wetlands. Tidal wetlands abut the Site’s entire eastern and southern boundaries. There was an absence of emergent and submerged aquatic vegetation along the ditches.

The largest area of nontidal wetland areas consists of a narrow riparian fringe emergent wetland and open-water along Berry’s Creek upstream of the tide gate along the northeast Site boundary. This fringe wetland is dominated by arrow arum, pickerel weed, and jewelweed. The two isolated areas are nontidal, open-water/emergent wetlands. The larger area is located between the two warehouse buildings on the Site. The smaller area is the on-site basin located in the undeveloped filled area. All Site wetlands are

considered Waters of the United States by the ACOE. Additional information about the Site's wetlands is provided in the Wetlands Delineation Report (Shisler 1997). Section 3.5.3 discusses the marsh area inundation.

3.7.4.2 Interagency Assessment of Wetland Functional Values, IVA Method

A summary of the interagencies' functional assessment of AA 4B (portion of Berry's Creek) using the IVA method is presented below:

<u>Wetland Function</u>	<u>Rating</u>
• Groundwater Recharge Effectiveness (GWR)	Low
• Groundwater Discharge Effectiveness (GWD)	Moderate
• Flood flow Alteration Effectiveness (FA)	Low
• Flood flow Alteration Opportunity (FAO)	Low
• Sediment Stabilization Effectiveness (SS)	High
• Sediment/Toxicant Retention Effectiveness (STR)	Moderate
• Sediment/Toxicant Retention Opportunity (STRO)	High
• Nutrient Removal/Transformation Effectiveness (NR)	High
• Nutrient Removal/Transformation Opportunity (NRO)	High
• Production Export Effectiveness (PE)	Moderate
• Aquatic Diversity and Abundance Effectiveness (ADA)	Low
• General Fish Habitat Effectiveness (FG3)	Moderate
• General Wildlife Habitat Effectiveness (GWL)	Low
• General Waterfowl Habitat Effectiveness (GWF)	High

These attribute scores can be grouped as follows:

<u>Low</u>	<u>Moderate</u>	<u>High</u>
GWR	GWD	SS
FA	STR	STRO
FAO	PE	NR
ADA	FG3	NRO
GWL		GWF

In general an equal number of attributes scored low and high. Aquatic and wetland general habitat values (ADA and GWL) scored low. However, general fish habitat (FG3) scored moderate and general waterfowl habitat (GWF) scored high.

Data collected during the interagency IVA were also utilized by the agencies to prepare the DEIS for the HMD Special Area Management Plan. The DEIS indexing method combined the wetland attributes recognized in the IVA into three major wetland attributes; Water Quality (SS, STR, STRO, NR, AND NRO), Wildlife Habitat (PE, ADA, FG3, GWL, and GWF), and Social Significance (FA, FAO, GWR, GWD).

The wetland attribute scores for AA 4B were: Water Quality = 87; Wildlife Habitat = 71; and Social Significance = 1. While we were not able to find an explicit definition of the rating scale in the DEIS, it was inferred from the text that the scale is from 0 to 100, with higher scores indicating higher or improved functions. The water quality score correlates well with the IVA ratings, as four of the five attributes that contribute to the water quality score were rated high and the fifth was rated moderate. The wildlife habitat score does not seem to correlate as well with the IVA ratings, as of the five contributing attributes, two were rated low, two were rated moderate, and only one was rated high. The wildlife habitat score may have been negatively influenced by the profuse growths of common reed. The social significance score did correlate well with the IVA ratings, as both of the contributing attributes were rated low in the IVA. The Berry's Creek wetlands were designated in the DEIS as "unimpacted wetlands." Unimpacted wetlands were defined in the DEIS as those that are unlikely candidates for mitigation either because of existing high quality, existing contamination issues, or very small size. Of these three choices, we speculate that the Berry's Creek wetlands were classified as "unimpacted" because of the existing contamination problem.

Both the interagency IVA and the DEIS included the agency assessment of AA 4B in their report presenting their evaluation of wetland functions and values of the entire Berry's Creek wetland system. Therefore the agencies' assessment of AA 4B is presented in the perspective of a larger assessment of the Berry's Creek ecosystem. The BPJ assessment performed by Dr. Shisler (described below), while considering the findings of the agencies' functional assessment, focused his assessment on the 16 acres of jurisdictional wetlands on the Site (the 12 acre marsh area and four additional acres of fringe and isolated wetlands on the Site).

3.7.4.3 Dr. Shisler's BPJ Assessment of Wetland Functional Values

Dr. Shisler conducted a BPJ qualitative assessment of the Site's wetlands, on May 22, 1997. This assessment used functional categories that are very similar to those used in the IVA method. Key differences are that:

- Dr. Shisler used a single (combined) functional description for flood flow alteration, sediment/toxicant retention, and nutrient removal/transformation, whereas the IVA method subdivides these functions
- Dr. Shisler did not assess the groundwater recharge/discharge functions included in the IVA assessment
- Dr. Shisler recognized recreational and conservation potential attributes that were not included in the IVA.

In assessing the wetland functions for the wetlands on the Site, Dr. Shisler gave each attribute a rating from 0 to 10 (with 0 representing no value and 10 representing the highest value). This contrasts with the high/moderate/low ratings used in the IVA

method. The assigned ratings and rationale for each attribute in Dr. Shisler's BPJ Assessment is listed in Table 3-7.

As shown on Table 3-7, Dr. Shisler's ratings varied significantly from the IVA ratings for the region that includes the Site wetlands, with some higher and some lower: both rated PE low to moderate and ADA and GWL low; Dr. Shisler rated FA/FAO much higher than the interagency assessment; and all other attributes were rated lower by Dr. Shisler than in the interagency assessment. These differences can most likely be attributed, at least in part, to Dr. Shisler's focus on the disturbed wetlands on the Site as contrasted to the IVA assessment done in the context of the entire Berry's Creek that included the Site wetlands.

3.7.5 Summary

In summary the Site's habitats have been impacted by historic human activities that have degraded both wetlands and uplands on the Site. The Site's wetland and upland habitats were found not to be diverse in terms of plant and wildlife. This lack of diversity, while not preventing aquatic and terrestrial wildlife use of the Site, does limit it to those species that can adapt to Site conditions that are primarily the result of anthropogenic influences. The pioneer forest plants that have colonized portions of the Site provide some degree of habitat diversity. While these plants increase the structural component of the habitat, other habitat features, such as a developed forest soil, are lacking. Therefore, it is likely that various habitat components are missing. For example, the poor quality of the substrate due to fill and debris probably limits the diversity and biomass of soil invertebrates. Likewise aquatic and wetland habitats are limited. The most obvious limitation of Site wetlands is the near monoculture of common reed that dominates the Site. Recent literature has indicated that common reed provides more habitat value than previously suspected. However, compared to a more natural habitat consisting of diverse wetland plants and associated animals the overall values of the Site's degraded habitats are judged to be low.

3.8 Demography and Land Use

The Site is located in an urban, industrialized area of Bergen County, just 6 miles west of New York City. The northern portion of the Site is located in the Borough of Wood-Ridge and the southern portion is located in the Borough of Carlstadt. Wood-Ridge is a borough of 1.1 mi² (704 acres). The population of Wood-Ridge was estimated to be 7,506 persons in the 1990 census, representing a decline of almost 10 percent since the 1970 census (8,311 persons) (The New Jersey Municipal Data Book 1997). Carlstadt is somewhat larger, at 4.2 mi² (2,688 acres). The population of Carlstadt was 5,510 persons according to the 1990 census, a decrease of greater than 10 percent from the 1980 census (6,166 persons) (The New Jersey Municipal Data Book 1998). There are approximately 11,600 people living within a 1-mile radius of the Site (U.S. EPA 1998).

The Site represents approximately 1 percent of the combined land areas of Wood-Ridge and Carlstadt. The Wood-Ridge portion of the Site (approximately 15.7 acres) includes all of the developed area and just less than half of the undeveloped filled area. Wood-Ridge has zoned this area as “light industrial park” (Kolicko 1997, pers. comm.). The Carlstadt portion of the Site (approximately 22.6 acres) includes all of the marsh area and just over half of the undeveloped filled area. This portion is located in a special zoning district regulated by HMC. This portion is zoned as “light industrial and distribution B” (HMDC 1986).

Single-story industrial structures and residential housing occupy the areas to the north and west of the Site, within the Borough of Wood-Ridge. The one-block area immediately north of the Site, between Blum Boulevard and Anderson Avenue, is zoned by the Borough of Wood-Ridge as “light industrial park.” Residential zoning exists 750 ft to the north, where there are approximately 50 residential properties, both single- and multi-family units (Thornley 1998, pers. comm.). This residential area continues to the north but is located in the Borough of Moonachie and is under the jurisdiction of the HMC. This area is zoned “low density residential” (HMDC 1986). Immediately to the west are warehouses and other industrial properties. Five hundred ft to the west is New Jersey State Route 17, a four-lane divided highway. Additional residential properties within the boroughs of Wood-Ridge and Carlstadt are located beyond Route 17 to the west.

4.0 Nature and Extent of Contamination

This discussion of the nature and extent of contamination is based on the data collected during the Phase I and Phase IA remedial investigations, the supplemental warehouse evaluation study, and NJDEP's previous investigations during the period 1990 to 1991 related to the Site. The text in Section 4 discusses the extent of SoPCs only for the specific media in which they were identified. The exception to this is for subsurface soils, where the occurrence of all SoPCs identified in groundwater or seeps is also discussed. The summary tables, however, include additional data as may be needed to support the assessment of SoPC fate and transport presented in Section 5. Each table, therefore, shows both the media-specific SoPCs and SoPCs identified for media that may potentially be on a transport pathway from the primary medium covered by the table. Media included with each set of tables are listed below.

Table Number:	Primary Medium In Table:	Other Media SoPCs Also Shown in Table:
4-1a, b, c	Onsite Surface Soil	Groundwater, Seeps, Surface Water, Sediment
4-2a, b, c	Onsite Subsurface Soil	Groundwater, Seeps
4-3a, b, c, d	Offsite Soil	None
4-4a, b, c, d	Groundwater	Seeps, Surface Water
4-5a, b	Seeps	Surface Water
4-6a, b, c	Surface Water	None
4-7a, b, c, d	Sediment	None

SoPCs for the specific medium shown in a given table are indicated by bold typeface, the others are shown in italics.

Complete tables of all Phase I and Phase IA investigation data, warehouse evaluation results, and NJDEP data summaries are presented in Appendix B. Data from OU1 is contained in Appendix B1 and data from OU2 is contained in Appendix B2. Chemical analysis results for quality assurance samples collected in the field (sample duplicates, equipment rinsate blanks, and trip blanks) are found in Appendix L. Data quality assurance review summaries, laboratory case narratives, and nonconformance summaries are presented in Appendix M.

Summary tables in this section include the number of analyses and undetected values for each SoPC, the minimum and maximum detected values, arithmetic averages, geometric means, the screening criteria values, and the number of screening criteria exceedances. It should be noted that for surface and subsurface soils, the presence of individual screening criteria exceedances does not necessarily govern selection as a SoPC for that media. Rather, compliance averaging procedures, as described in Section 1.4, are used in the selection of surface and subsurface soil SoPCs. Arithmetic average and geometric mean SoPC concentrations were calculated using detected values and one-half of the reported

instrument detection limits (IDL) for undetected values. Undetected results for samples that were diluted prior to analyses, resulting in elevated detection limits, were not used in the calculations.

The summary tables do not include the chemical analysis results from the NJDEP investigation in 1990 since we do not have enough information about those results to present statistical information comparable to that presented for the rest of the investigation results. The concentrations reported by the NJDEP are, however, shown on figures and discussed in the text.

Section 4 is organized into eight subsections. Sections 4.1 through 4.5 discuss the nature and extent of SoPCs in the various media: soil, groundwater, leachate/seeps, surface water, and sediment. Sections 4.1 through 4.5 are organized into subsections that discuss the data in the following order: mercury, other metals, and organic compounds. The summary tables and discussions are also organized in terms of the two operable units: OU1 (the developed and undeveloped filled areas) and OU2 (the marsh area). OU1 is further divided into the developed area and the undeveloped area, where appropriate. Section 4.6 discusses the results of air sampling performed during Phase I, during the NJDEP investigations, and during the supplemental warehouse evaluation study. Section 4.7 discusses the concentrations of substances found at elevated levels in the discretionary samples of material collected during the trenching activities and hazardous substance inventory investigation. Section 4.8 discusses the results of the soil material collected from the warehouse sub-floor during the supplemental warehouse evaluation study. Finally, Section 4.9 discusses the data quality assessment.

The OU1 results presented in this section support the transport and fate discussion in Section 5, as well as the future baseline human health and ecological risk assessments and feasibility study. The OU2 results are discussed in Section 5 only for the purpose of assessing the significance of potential migration from OU1 to OU2. Further interpretation of OU2 results will be deferred until further work on OU2 is undertaken.

In order to present all relevant data, several of the Section 4 figures are very crowded with data. The extensive data shown on these figures make it difficult to also show the sample station identification. Please refer to Figures 2-1a through 2-1e for specific station identification.

4.1 Soils

4.1.1 Onsite Surface Soil Analyses

This section discusses concentrations of SoPCs in surface soils collected from 200-ft intervals on the 100×100-ft control grid established on the Site and from the surface soil intervals for the boreholes in which the three Phase IA monitoring wells were installed (MW-13, MW-14, and MW-15). The results of the three surface soil samples collected

from the developed area adjacent to the U.S. Life (Jerbil) warehouse during the warehouse evaluation study are also incorporated in this discussion. Onsite surface soils are defined as material collected from the 0- to 2-ft soil horizon, with rocks and debris removed. Six metals (arsenic, copper, lead, mercury, thallium, and zinc) and one SVOC (benzo[a]pyrene) were identified as SoPCs based on comparison with the NRDCSCC, and an additional 12 metals (aluminum, antimony, barium, cadmium, chromium, cobalt, iron, manganese, nickel, selenium, silver, and vanadium) and one additional SVOC (bis[2-ethylhexyl]phthalate [DEHP]) were identified as SoPCs based on the ecological screening criteria (see Section 1.4).

Tables 4-1a, b, and c provide summaries of chemical analysis results for these SoPCs (onsite surface soils) and SoPCs identified in groundwater, seeps, surface water, and sediment. Table 4-1a summarizes all of the OU1 data, while 4-1b and 4-1c summarize just the developed area and undeveloped filled area data, respectively. Complete chemical analysis results for onsite surface soil samples are presented in Appendix B1, Table B1-1. Chemical analyses for surface soil intervals from boreholes are presented in Appendix B1, Tables B1-2a through f. Note that the sample from the 1- to 3-ft depth at MW-13 is considered a surface soil sample because approximately 9–12 in. of asphalt and gravel were removed from the surface before the first soil sample was taken. The chemical analysis results for surface soil samples collected during the warehouse evaluation are presented in Appendix B1, Table B1-3.

4.1.1.1 Mercury

Figures 4-1 and 4-2 show the mercury and methylmercury concentrations, respectively in surface soils. Figure 4-2 also shows the methylmercury concentration as a percentage of the total mercury concentration. The highest mercury concentration in surface soils from the Site was measured at location SS-04 (13,800 mg/kg), in the developed area near the vicinity of the former mercury processing plant. Small beads of elemental mercury were visible in this sample, which was collected from underneath the asphalt pavement. Mercury concentrations in the remaining 13 samples collected from the developed area ranged from 9.3 to 4,480 mg/kg (Table 4-1b).

Historical data for mercury concentrations in soil in the developed area of the Site are summarized in the BITM (Volume 4). Soil samples were collected from 34 locations in 1974 in the area where the Wolf Warehouse now stands (JMA 1977). These data are reported in Figure B-5 and Table B-1 of the BITM. These data were obtained prior to construction of the Wolf Warehouse and can only be interpreted in the most general sense because grading and addition of fill probably occurred prior to construction of the warehouse. Samples were collected primarily from the surface (i.e., 6 or 8 in. to 12 in. depth), 1–2 ft bgs interval, and 2–3 ft bgs interval. The mean mercury concentration for these samples was 12,800 mg/kg.

One sample was collected in 1977 (after construction of the warehouses) on the southeast side of the Wolf Warehouse in the developed area (JMA 1977). Mercury data from this

location (23S) are reported in Table 3-1 of the BITM. Mercury concentrations were 2,558 mg/kg at 0–6 in. depth, 2,885 mg/kg at 6–12 in. depth, 3,397 mg/kg at 12–18 in. depth, and 4,719 mg/kg at 18–24 in. depth.

In the undeveloped filled area, mercury concentrations ranged from 1.2 to 548 mg/kg (Table 4-1c). The sample collected from the southern-most location in the undeveloped area (SS-34) exhibited the lowest concentration (1.2 mg/kg), whereas the highest concentration was measured at location SS-20 (548 mg/kg), near the center of this area. The mean mercury concentration in the undeveloped filled area surface soils is more than an order of magnitude lower than in the developed area. No soil samples collected from the Site had mercury concentrations below IDLs.

Methylmercury concentrations were measured in four samples along the transect bordering the Diamond Shamrock/Henkel Ditch (north) and in five samples from other locations in the undeveloped filled area (Figure 4-2). Concentrations ranged from 0.00059 to 0.322 mg/kg, with the lowest and highest values occurring at the same locations as for total mercury.

4.1.1.2 Other Metals

Figures 4-3 through 4-7 show concentrations of metals (other than mercury) identified as SoPCs in the surface soils based on the NRDCSCC. The distributions for these five metals are discussed briefly below. Further discussion of the distribution of the metals identified as SoPCs based on the ecological screening criteria only is deferred until the ecological risk assessment is prepared.

- **Arsenic**—Arsenic concentrations exceeded the NRDCSCC in only the sample from 0- to 2-ft at MW-14 (Figure 4-3). The geometric mean arsenic concentration was twice as high in the undeveloped area as in the developed area (Tables 4-1b and 4-1c). Concentrations in the undeveloped filled area ranged from 4.3 to 26.4 mg/kg, with a geometric mean of 6 mg/kg, while concentrations in the developed area ranged from 2.1 to 11 mg/kg, with a geometric mean of 3 mg/kg (Tables 4-1b and 4-1c).
- **Copper**—Copper concentrations exceeded the NRDCSCC in three surface soil samples: SS-20, SS-24, and MW-15 (Figure 4-4). Concentrations in the undeveloped filled area ranged from 22.8 to 1,010 mg/kg, with a geometric mean of 150 mg/kg, while concentrations in the developed area ranged from 12 to 7,420 mg/kg, with a geometric mean of 90 mg/kg (Tables 4-1b and 4-1c).
- **Lead**—Lead concentrations exceeded the NRDCSCC in 6 of the 39 surface soil samples from the undeveloped filled area, but in none from the developed area (Figure 4-5). Concentrations in the

undeveloped filled area ranged from 39.3 to 4,320 mg/kg, with a geometric mean of 400 mg/kg, while concentrations in the developed area ranged from 17.8 to 390 mg/kg, with a geometric mean of 80 mg/kg (Tables 4-1b and 4-1c).

- **Thallium**—Thallium exceeded the NRDCSCC in only 3 of the 39 soil samples from Phases I and IA (Figure 4-6). Two samples from the undeveloped filled area (SS-08 and SS-20) had thallium concentrations of 14.5 and 21.9 mg/kg, respectively, and the sample from the 0- to 2-ft depth at MW-15 had a thallium concentration of 5.4 mg/kg. Additionally, the 0-to-2-ft sample from the borehole for MW-7 had a thallium concentration of 10 mg/kg.
- **Zinc**—Zinc concentrations exceeded the NRDCSCC in 6 of the 39 surface soils samples (Figure 4-7). The highest concentrations of zinc in the undeveloped filled area were located at SS-08 (14,400 mg/kg), SS-20 (25,400 mg/kg), and the borehole for MW-7 (10,600 mg/kg). Concentrations of zinc from the remaining sample locations in the undeveloped area ranged from 192 to 6,570 mg/kg. In the developed area, concentrations ranged from 88.9 to 2,110 mg/kg. The geometric mean zinc concentration in the undeveloped filled area was 700 mg/kg and 400 mg/kg in the developed area.

4.1.1.3 Organic Compounds

Benzo[a]pyrene was the only SVOC identified as an SoPC for onsite surface soils based on the NRDCSCC criteria, and DEHP was the only organic SoPC identified based on the ecological screening criteria.

Figure 4-8 shows the distribution of benzo[a]pyrene in surface soils and sediments. Nine of the eleven screening criteria exceedances were in the undeveloped filled area and two were in the developed area. The highest concentrations were from sample locations SS-17 (3,200 $\mu\text{g/kg}$) and SS-29 (10,000 $\mu\text{g/kg}$), adjacent to the western Site property line that borders Randolph Products and Diamond Shamrock/Henkel. DEHP concentrations exceeded the ecological screening criteria only in the sample from SS-18.

4.1.2 Onsite Subsurface Soil Analyses

Seven metals (arsenic, beryllium, copper, lead, mercury, thallium, and zinc) and four SVOCs (benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, and dibenz[a,h]anthracene) were identified as SoPCs for subsurface soils based on the NRDCSCC. Eight additional metals (antimony, barium, cadmium, chromium, nickel, selenium, silver, and vanadium) were identified as SoPCs for subsurface soils based on EPA SSLs for

migration to groundwater (with a dilution-attenuation factor of 1). No subsurface soil SoPCs were identified based on the impact to groundwater soil screening criteria. There were a few individual IGWSCC criteria exceedances, but no substances for which the Site average value exceeded the IGWSCC. For inorganics, however, there are no published IGWSCC values. Rather, footnote “h” to the NJDEP Soil Cleanup Criteria table (last revised 5/2/99) states, “The impact to ground water values for inorganic constituents will be developed based on site specific chemical and physical parameters.” In lieu of developing such site-specific criteria, the distribution in subsurface soil of all SoPCs identified for groundwater and seeps is discussed below. Ten metals (antimony, arsenic, cadmium, iron, lead, manganese, mercury, nickel, selenium, and thallium), sodium, and five VOCs (benzene, chlorobenzene, 1,2-dichloroethene isomers, toluene, and xylene isomers) were identified as SoPCs in groundwater and seeps (see Section 1.4).

Tables 4-2a, b, and c provide summaries of chemical analysis results for the subsurface soil SoPCs and the groundwater and seep SoPCs. Table 4-2a includes all subsurface soils samples (with the exception of the four samples from the Phase IA SFI that were analyzed for mercury only), while Tables 4-2b and 4-2c summarize the test pit samples and borehole samples separately. Complete chemical analysis results for subsurface soil samples are presented in Appendix B1, Tables B1-4a, b, and c (test pit samples); Tables B1-2a and b (Phase IA borehole samples); and Tables B1-2c, d, e, and f (NJDEP borehole samples).

Subsurface soil samples were collected from 20 test pits located in the undeveloped filled area of the Site, from the boreholes during well installation, and from one borehole (borehole B-5) during the Phase IA SFI in 2002. Two subsurface soil samples were collected from each of test pits 1–10 and 13–20. A single subsurface soil sample was collected from test pits 11 and 12, because the depths of these test pits were less than 3 ft. Data availability for the well installation boreholes is variable. Samples from the three well installation boreholes in Phase IA were analyzed for target metals and VOCs (Table 2-2). For the 12 wells installed by the NJDEP in 1990, samples were analyzed for a wide range of analytes, but only concentrations above the then current screening criteria values were found in the NJDEP files. Samples from the Phase IA SFI were analyzed for mercury only.

In addition, nine discretionary solid material samples were collected from the test pits. These discretionary samples were selected where discolored material or waste deposits were evident in the test pits and were not part of the 2-ft soil intervals sampled from the test pits. Therefore, the chemical analysis results from these samples are discussed in Section 4.7, Hazardous Substances Inventory, except that they are mentioned in this section when the results may be relevant to understanding the concentrations measured in the soil samples.

4.1.2.1 Mercury

Mercury concentrations in the 45 onsite subsurface soil samples from Phases I and IA ranged from 0.19 to 34,700 mg/kg (Figure 4-9). Mercury concentrations in the four onsite subsurface soil samples (all from borehole B-5) from the Phase IA SFI in 2002 were also in this range. Elemental mercury was not observed during this investigation. Mercury vapor concentrations in soils exceeded 0.5 mg/m³ at 6–8 ft bgs (0.698 mg/m³) and 8–10 ft bgs (0.861 mg/m³). Mercury vapor concentrations in soils were not measured in previous investigations.

The highest mercury concentration in subsurface soils was in the sample from the 4- to 6-ft depth at TP-17. Debris encountered in this test pit included wood, metal scraps, tires, shingles, drums, tarpaper, and a white-yellow substance. The second highest subsurface mercury soil concentration, 5,150 mg/kg in the 3- to 3.5-ft interval at MW-13, was nearly an order of magnitude lower than the highest concentration.

Mercury was also analyzed in 71 subsurface soil intervals collected during the installation of 12 monitoring wells by NJDEP in 1990 (NJDEP 1993a). Soils were analyzed in 2-ft intervals from soil borings that ranged from 14.5 to 20 ft in total depth (Figure 4-9). The highest concentration of mercury in any of these subsurface samples was from the 8- to 10-ft depth at MW-6 (1,550 mg/kg). The samples with the lowest mercury concentrations were collected from sample intervals generally greater than 12 ft deep.

As discussed in Section 4.1.1.1, surface and subsurface soil samples were collected in 1974 in the area where the Wolf Warehouse now stands and in 1977 (after construction of the warehouses) at one location adjacent to the Wolf Warehouse (JMA 1977). These data are summarized in the BITM. The 1974 data were obtained prior to construction of the Wolf Warehouse and can only be interpreted in the most general sense because grading and addition of fill probably occurred prior to construction of the warehouse. The 1977 mercury concentrations for the one location adjacent to the Wolf Warehouse ranged from 2,885 to 4,719 mg/kg at subsurface depths between 6 and 24 in. (JMA 1977).

4.1.2.2 Other Metals

The following distributions were found for metals other than mercury in subsurface soil samples collected from test pits and well boreholes. Of the metals discussed below, barium, beryllium, chromium, copper, silver, vanadium, and zinc were identified as SoPCs only in subsurface soils; iron, manganese, and sodium were identified as SoPCs only in groundwater or seeps; and antimony, arsenic, cadmium, lead, nickel, selenium, and thallium were identified as SoPCs in both subsurface soils and groundwater or seeps.

- **Antimony**—Antimony was detected in 33 of 40 Phase I subsurface soil samples at concentrations ranging from 0.36 to 41.2 mg/kg. Phase IA subsurface soil samples were not analyzed for antimony. The EPA SSL was exceeded in all samples where antimony was detected. None of the concentrations exceeded the NRDCSCC value.
- **Arsenic**—Arsenic was detected in all but one Phases I and IA subsurface soil samples, in concentrations ranging from 1.4 to 120 mg/kg (Figure 4-3). Arsenic concentrations exceeded the NRDCSCC in six samples from five test pits (TP-01, 02, 10, 14, and 15) and two samples from the boreholes (MW-6 and MW-14). All of the detected concentrations exceeded the EPA SSL.
- **Barium**—Barium was detected in all Phase I and IA subsurface soil samples at concentrations ranging from 29.5 to 1,290 mg/kg. Concentrations in 38 of 45 samples exceeded the EPA SSL value. None of the concentrations exceeded the NRDCSCC value.
- **Beryllium**—Beryllium was detected only in two samples, the 5.5- to 7.5-ft depth at TP-10 (2.1 mg/kg) and the 6- to 8-ft depth at TP-17 (1.1 mg/kg). The concentration at TP-10 exceeded the NRDCSCC. None of the detected concentrations exceeded the EPA SSL.
- **Cadmium**—Cadmium was detected in all Phases I and IA subsurface soil samples, ranging in concentration from 0.4 to 36.1 mg/kg (Figure 4-10). None of the concentrations exceeded the NRDCSCC value.
- **Chromium**—Chromium was detected in all Phase I and IA subsurface soil samples at concentrations ranging from 6.4 to 606 mg/kg. All of the concentrations exceeded the EPA SSL. There is no NRDCSCC value for chromium.
- **Copper**—Copper was detected in all Phases I and IA subsurface soil samples, in concentrations ranging from 6.73 to 2,190 mg/kg (Figure 4-4). The samples in which copper concentrations exceeded the NRDCSCC were collected from TP-05, TP-10, and TP-15. Relatively high concentrations of both arsenic and copper were measured in the sample collected from a depth of 3 to 5 ft in test pit TP-15. A discretionary sample consisting of red pigment material was collected from a depth of 4 ft in this same test pit (Table B1-5). This material did not have high concentrations of arsenic or copper, indicating that the red pigment is not the source of elevated arsenic or copper levels. There is no EPA SSL for copper.

- **Iron**—Iron was detected in all Phases I and IA subsurface soil samples, in concentrations ranging from 1,840 to 293,000 mg/kg (in the 3- to 5-ft depth from TP-15). The next highest iron concentration in a subsurface soil sample was also from TP-15 (103,000 mg/kg in the 5- to 7-ft depth). The discretionary sample taken at the 4-ft depth in TP-15 had an iron concentration of 90,800 mg/kg. The third highest subsurface soil iron concentration was 71,100 mg/kg in the sample from TP-17 in the 4- to 6-ft depth.
- **Lead**—Lead was detected in all Phases I and IA subsurface soil samples, in concentrations ranging from 5 to 3,830 mg/kg (Figure 4-5). Concentrations in 25 of the 39 samples from the undeveloped filled area exceeded the NRDCSCC, while none of the subsurface soil samples from the developed area exceeded the NRDCSCC. Concentrations in 30 of the 45 samples exceeded the EPA SSL; one of these samples (collected at MW-13) was from the developed area. The highest concentration of lead (3,830 mg/kg) was in the sample collected from the 3- to 5-ft depth in test pit TP-07. A discretionary sample collected near the surface of TP-07 consisted of a hard white substance, and also had a high concentration of lead (6,020 mg/kg).
- **Manganese**—Manganese was detected in all Phases I and IA subsurface soil samples, in concentrations ranging from 16.5 to 23,300 mg/kg. The highest concentration was in the sample from the 7- to 9-ft depth in TP-03. The second highest concentration, 908 mg/kg in the sample from the 3- to 5-ft depth at TP-15, was more than an order of magnitude lower than the highest concentration.
- **Nickel**—Nickel was detected in all Phases I and IA subsurface soil samples, in concentrations ranging from 8.2 to 317 mg/kg (Figure 4-11). No subsurface soil nickel concentrations exceeded the NRDCSCC. All concentrations exceeded the EPA SSL. Concentrations above 100 mg/kg were found in samples from TP-05, TP-07, TP-08, TP-10, TP-15, TP-18, and TP-19.
- **Selenium**—Selenium was detected in 16 of the 45 subsurface soil samples in Phases I and IA, in concentrations ranging from 0.84 to 6.4 mg/kg. No subsurface soil selenium concentrations exceeded the NRDCSCC. Concentrations in 16 of the 45 samples exceeded the EPA SSL. The highest concentrations were found in samples from TP-12, TP-03, and TP-02. Selenium was reported as undetected at an elevated detection limit of 8.8 mg/kg in the sample from the 3- to 5-ft depth at TP-15.

- **Silver**—Silver was detected in 36 of 45 subsurface soil samples from the Phase I and IA investigations at concentrations ranging from 0.16 to 84.8 mg/kg. Concentrations exceeded the EPA SSL in 19 of the 36 samples where silver was detected.
- **Sodium**—Sodium was detected in 18 of the 40 subsurface soil samples, in concentrations ranging from 63 to 2780 mg/kg. The highest value, from TP-12, was nearly twice as high as the second highest value, from TP-16. There is no NRDCSCC or EPA SSL for sodium.
- **Thallium**—Thallium was detected in only 4 of 45 subsurface soil samples (collected at MW-13, TP-03, TP-04, and TP-05). All of the detected concentrations exceeded the EPA SSL, while concentrations in the test pit samples (TP-03, TP-04, and TP-05) also exceeded the NRDCSCC (Figure 4-6). The test pit samples in which thallium was detected were all collected from deep sampling intervals in an area of the Site that contains a considerable amount of construction debris. A discretionary sample collected from a depth of 3 ft at TP-05 consisted of a white, pasty substance and had a thallium concentration below the IDL (Table B-4), indicating that it was not the thallium source.
- **Vanadium**—Vanadium was detected in all Phase I and IA subsurface soil samples at concentrations ranging from 7.4 to 980 mg/kg. No subsurface soil vanadium concentrations exceeded the NRDCSCC. Concentrations in 2 of the 40 samples exceeded the EPA SSL. These two exceedances were from TP-12 (980 mg/kg at 1-3 ft) and TP-20 (304 mg/kg at 2-4 ft).
- **Zinc**—Zinc was detected in all Phases I and IA subsurface soil samples, in concentrations ranging from 26.8 to 43,200 mg/kg (Figure 4-7). Concentrations in 34 of the 45 subsurface soil samples exceeded the EPA SSL. Concentrations in 14 of the 39 subsurface soil samples from the undeveloped filled area exceeded the NRDCSCC, while neither of the subsurface soils samples from the developed area exceeded the NRDCSCC. The highest concentration of zinc was in a sample collected from a depth of 4- to 6-ft at TP-17. The highest mercury concentration was also in this sample. The second highest subsurface soil zinc concentration (4,960 mg/kg in the sample from the 3- to 5-ft depth at TP-15) was nearly an order of magnitude lower than the highest concentration. Also, the discretionary samples from the 4-ft depth in TP-19 and near the surface at TP-07 had zinc concentrations of 9,040 mg/kg and 7,980 mg/kg, respectively.

4.1.2.3 Organic Compounds

The VOCs in this section are discussed only because they were identified as SoPCs for groundwater or seeps. None of the VOCs discussed here have been identified as SoPCs for subsurface soil. The SVOCs are discussed because they were identified as SoPCs for subsurface soils.

- **Benzene**—Benzene was detected in only the following 5 of 41 Phases I and IA subsurface soil samples: the 4.5- to 6.5-ft depth at TP-13 (10 $\mu\text{g/kg}$), the 6.5- to 8.5-ft depth at TP-13 (8 $\mu\text{g/kg}$), the 4.5- to 5-ft depth at MW-13 (4.8 $\mu\text{g/kg}$), the 6.5- to 7-ft depth at MW-13 (1.5 $\mu\text{g/kg}$), and the 2- to 4-ft depth at MW-14 (6.5 $\mu\text{g/kg}$). The IGWSCC for benzene is 1000 $\mu\text{g/kg}$. Benzene did not exceed the NRDCSCC or IGWSCC in any subsurface soil sample.
- **Chlorobenzene**—Chlorobenzene was detected in only 1 of 41 Phase I and IA subsurface soil samples, in the 5.5- to 7.5-ft depth of TP-10 (10 $\mu\text{g/kg}$). The IGWSCC for chlorobenzene is 1000 $\mu\text{g/kg}$. Chlorobenzene did not exceed the NRDCSCC or IGWSCC in any subsurface soil sample.
- **1,2-Dichloroethene Isomers**—1,2-Dichloroethene isomers were not detected in any Phases I and IA subsurface soil samples.
- **Toluene**—Toluene was detected in only the following 4 of 41 subsurface soil samples: the 4.5- to 6.5-ft depth at TP-13 (23,000 $\mu\text{g/kg}$), the 6.5- to 8.5-ft depth at TP-13 (70,000 $\mu\text{g/kg}$), 4- to 6-ft depth at TP-18 (15 $\mu\text{g/kg}$), and the 2- to 4-ft depth at MW-14 (6.4 $\mu\text{g/kg}$). The IGWSCC for toluene is 500,000 $\mu\text{g/kg}$. Toluene did not exceed the NRDCSCC or IGWSCC in any subsurface soil sample.
- **Xylene Isomers**—Xylene isomers were detected in only the following 3 of 41 Phases I and IA subsurface soil samples: the 4.5- to 6.5-ft depth at TP-13 (22,000 $\mu\text{g/kg}$), the 6.5- to 8.5-ft depth at TP-13 (110,000 $\mu\text{g/kg}$), and 4- to 6-ft depth at TP-18 (97 $\mu\text{g/kg}$). The IGWSCC for xylenes (total) is 67,000 $\mu\text{g/kg}$. Xylene did not exceed the NRDCSCC in any subsurface soil sample. One sample (TP-13) exceeded the IGWSCC; however, xylene is not considered as a subsurface SoPC due to compliance averaging (see Appendix B3, Table B3-2).
- **Benzo[a]anthracene**—Benzo[a]anthracene concentrations in subsurface soil samples ranged from 55 to 62,000 $\mu\text{g/kg}$. The highest concentration was more than an order of magnitude greater than the second highest concentration (4,200 $\mu\text{g/kg}$ in TP-14). Only those two samples had concentrations greater than the NRDCSCC.

- **Benzo[a]pyrene**—Benzo[a]pyrene concentrations in subsurface soil samples ranged from 72 to 52,000 $\mu\text{g/kg}$ (Figure 4-8). Ten samples had concentrations greater than the NRDCSCC. The highest benzo[a]pyrene concentration was from the 4- to 6-ft depth at TP-18. The second highest concentration, from TP-14, was an order of magnitude lower than the highest concentration. Concentrations in the remaining seven samples with concentrations above the NRDCSCC ranged from 740 to 1200 $\mu\text{g/kg}$.
- **Benzo[b]fluoranthene**—Benzo[b]fluoranthene concentrations ranged from 74 to 64,000 $\mu\text{g/kg}$. Only samples from the 4- to 6-ft depth at TP-18 (64,000 $\mu\text{g/kg}$) and the 4- to 6-ft depth at TP-14 (7,000 $\mu\text{g/kg}$) exceeded the NRDCSCC. The sample at TP-18 also exceeded the IGWSCC. As with benzo[a]pyrene, the highest concentration was approximately on order of magnitude higher than the second highest concentration.
- **Dibenz[a,h]anthracene**—Dibenz[a,h]anthracene concentrations in subsurface soil samples collected from the test pits ranged from 53 to 1,300 $\mu\text{g/kg}$. Only the sample from the 4- to 6-ft depth at TP-18 had dibenz[a,h]anthracene concentration above the NRDCSCC. The second highest concentration, 600 $\mu\text{g/kg}$ in TP-14, was less than half of the highest concentration.

4.1.3 Offsite Soil Analyses

This section summarizes SoPC concentrations in offsite surface and subsurface soils. During Phase I, offsite surface soils were collected from 22 locations on a grid pattern approximately 200×200 ft on the properties adjacent to the north property boundary of the Site. Four additional locations adjacent to the Norfolk Southern Railroad spur to the west of the Site were sampled during Phase IA. During the Phase IA SFI in 2002, offsite soil samples were collected from six borehole locations along the northern property boundary.

Phase I offsite surface soils are defined as material collected from the 0- to 0.5-ft soil horizon, with rocks and debris removed. A specific chemical indicator list was developed for these offsite soils, as discussed in Section 1.4, *Substances of Potential Concern*. Two metals (lead and mercury) and six SVOCs (benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, dibenz[a,h]anthracene, and indeno[1,2,3-cd]pyrene) were identified as SoPCs based on the RDCSCC. Additionally, copper and zinc were identified as SoPCs based on exceedances of ecological screening criteria.

The Phase IA offsite soil samples were collected from the 0- to 2-ft and the 2- to 4-ft soil horizons, with rocks and debris removed. The surface interval (0- to 2-ft) was analyzed

for mercury and the bottom interval (2- to 4-ft) was archived. For the Phase IA SFI in 2002, the intent was to analyze soil samples to a depth of 6 ft bgs (i.e., 0–2, 2–4, and 4–6 ft sample intervals) or until mercury concentrations did not exceed the RDCSCC.

Tables 4-3a, b, c, and d provide summaries of chemical analysis results for SoPCs in offsite soil. Table 4-3a summarizes analyte concentrations in all of the offsite surface soil samples, while Tables 4-3b and 4-3c summarize analyte concentrations in surface soils that are adjacent to the Site and those not adjacent to the Site, respectively. Table 4-3d summarizes mercury concentrations in offsite soil boreholes from the Phase IA SFI in 2002. Complete chemical analysis results for offsite soil samples are presented in Appendix B1, Tables B1-6a, b, and c.

4.1.3.1 Mercury

The highest mercury concentration in offsite surface soils from the Phase I investigation was at sample location SS-67 (554 mg/kg), near the corner of Ethel Boulevard and Park Place East (Figure 4-1). The remaining samples collected from locations adjacent to the Site (SS-68 through SS-78 and B-9 through B-14) had mercury concentrations that ranged from 0.33 to 240 mg/kg, and most of the samples along the northern property boundary exceeded the RDCSCC. All other offsite sample locations not adjacent to the Site, with the exception of SS-63 (16.6 mg/kg), near the middle of the offsite sampling area, had mercury concentrations below the RDCSCC. Two samples had mercury levels below IDLs.

All four offsite soil samples collected from the surface interval adjacent to the Norfolk Southern Railroad during the Phase IA investigation had mercury concentrations below the RDCSCC. Because the surface interval did not exceed the RDCSCC, the archived bottom interval was not analyzed.

In the Phase IA SFI, no offsite samples exceeded the NRDCSCC of 270 mg/kg. Samples at several borehole locations exceeded the RDCSCC of 14 mg/kg as follows: B-9 (0–2 ft bgs), B-10 (0–2 and 4–6 ft bgs), B-11 (4–6 ft bgs), B-13 (0–2, 4–6, 6–8, 8–10, and 12–14 ft bgs), and B-14 (0–2 and 4–6 ft bgs). The highest subsurface mercury soil concentration in the Phase IA offsite boreholes was 172 mg/kg in the 4- to 6-ft interval at B-13. Mercury was delineated vertically to below the RDCSCC at all borehole locations, with one exception. At borehole B-13, the mercury concentration in the second deepest interval (10–12 ft bgs) was 0.75 mg/kg and the mercury concentration in the deepest interval (12–14 ft bgs) was 31.0 mg/kg. Data are presented on Figure 4-1.

In 1990, NJDEP (1990) sampled soils to a depth of 7 ft on the property north of the area formerly occupied by the Wood-Ridge POTW (north of offsite sample location SS-58). Mercury was analyzed in samples collected from three depths at six locations. Mercury concentrations in surface soils (0–1 ft) ranged from 1.4 to 21.4 mg/kg. Mercury concentrations in soils from the 3- to 5-ft depth interval ranged from 0.11 to 5.1 mg/kg. Samples from the 6- to 7-ft depth interval were equal to or less than 0.13 mg/kg. These

results are not shown on Figure 4-1 because more specific information on the sample locations was not found.

4.1.3.2 Other Metals

The lead concentration exceeded the RDCSCC at one offsite location, SS-72 (410 mg/kg). This sample was located in the vacant lot north of the Site that was formerly a POTW (Figure 4-5). All other metals concentrations were below the RDCSCC values.

Copper, lead, and zinc concentrations exceeded ecological screening criteria at several offsite locations. All of these locations are covered by asphalt pavement or gravel. Further discussion of these ecological criteria exceedances will be deferred to the ecological risk assessment.

4.1.3.3 Organic Compounds

Concentrations exceeding the RDCSCC criteria were measured at 8 offsite surface soil locations for benz[a]anthracene; 10 locations for benzo[a]pyrene; 12 locations for benzo[b]fluoranthene; 3 locations for benzo[k]fluoranthene; 3 locations for dibenz[a,h]anthracene; and 4 locations for indeno[1,2,3-cd]pyrene. Soil collected at sample location SS-63 had the highest concentrations for each of these six SVOCs. This sample was collected from a narrow strip of vegetated land between the Winston Corrugated Box Company building and the paved parking lot. Sample locations SS-53 and SS-60 also had concentrations of these six SVOCs that exceeded the RDCSCC. Higher concentrations were often associated with samples that contained pieces of asphalt paving material, or with areas that receive runoff from the asphalt parking lots. Figure 4-12 shows the distribution in offsite soils of these SVOCs.

4.1.4 Diamond Shamrock/Henkel Soil Analyses

This section summarizes SoPC concentrations in soils collected during two separate investigations of the Diamond Shamrock/Henkel facility by IT Corporation on behalf of Henkel. The data were obtained for this report from NJDEP in the form of five large maps that presented analyte concentrations exceeding Environmental Cleanup Responsibility Act guidelines or New Jersey residential cleanup criteria (IT 1991a,b,c,d; IT 1998). Data tables and a sample location figure were developed from the figures provided by NJDEP and are included in Appendix Q.

During the investigation in 1990, soil samples were collected at more than 150 locations in 0.5-ft intervals to depths of up to 9 ft. With the exception of a few samples on the southeast boundary, these locations were on the Diamond Shamrock/Henkel site. During

the investigation in 1998, soil samples were collected at up to 40 locations in 0.5-ft intervals to depths of up to 8 ft. These locations were offsite along three sides of the Diamond Shamrock/Henkel site and are termed *perimeter* samples. The southeast perimeter (i.e., along the West Ditch) was not sampled with the exception of samples collected in the Diamond Shamrock/Henkel ditch (south). It should be noted that extensive remedial activity occurred at the Site in the 1990s; therefore, data from the 1990 investigation may not reflect current conditions.

4.1.4.1 Mercury

In soils (or sediment) on the Diamond Shamrock/Henkel site, mercury was reported at most locations, with most of the highest concentrations from locations in the pond (Figure Q-1, Table Q-2). The pond has been remediated. The maximum concentration (1,300 mg/kg) was reported for B-69 in the outlet channel (Diamond Shamrock/Henkel ditch [north]). In the perimeter soils, mercury concentrations were reported (i.e., exceeding NJDEP residential cleanup criteria) only at PS-11 (located along 12th Street), PS-26 and PS-27 (located south of a bermed area at the southern end of the Site), and at most locations in the Diamond Shamrock/Henkel ditch (south) (Table Q-3). Reported concentrations were limited to the 0-to-0.5-ft depth interval with the exception of some locations in the ditch where concentrations were reported for the 1.5- to 2.0-ft depth interval. The maximum reported concentration was 334 mg/kg in the ditch at PS-37 in the 0- to 0.5-ft depth interval.

4.1.4.2 Other Metals

In soils on the Diamond Shamrock/Henkel site, arsenic, cadmium, chromium, copper, lead, and zinc were most frequently reported, with zinc concentrations usually higher than the other metals (Table Q-2). In the perimeter soils, other metals were only occasionally reported (Table Q-3). Zinc was most frequently reported, at locations near the northern corner of the Site and in the Diamond Shamrock/Henkel ditch (south) (Figure Q-1). Cadmium and arsenic were reported at most locations in the Diamond Shamrock/Henkel ditch (south).

4.1.4.3 Organic Compounds

In soils on the Diamond Shamrock/Henkel site, VOCs, PCBs, and pesticides were reported infrequently (Table Q-1). Base/neutral and acid extractable organic compounds were more frequently reported (Table Q-1). In the perimeter soils, organic compounds (usually benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, and benzo[k]fluoranthene) were reported at most locations (Figure Q-1, Table Q-3).

4.1.4.4 Potential for Offsite Transport

Of the data discussed above, only stations PS-20, PS-21, and PS-22, which are located on Randolph Products Property, are close enough to the Ventron/Velsicol Site, in general, and monitoring well MW-15, in particular, to be relevant to a discussion of possible offsite transport.

Based on the information provided by NJDEP, no data were reported for PS-20 and only one analyte was reported for PS-21 (copper at 1,910 mg/kg in the 2- to 2.5- ft depth interval). Analyte concentrations were reported for PS-22 at the 0.5- to 1.0- ft (antimony, cadmium, lead, zinc, individual SVOCs, and Aroclors[®] 1254 and 1260) and 3.5- to 4-ft (cadmium only) depth intervals. Mercury was not reported for any of these stations, at any depth (i.e., concentrations, if detected, were less than RDCSCC of 14 mg/kg).

In comparison to data from the 0-to-2- ft interval at MW-15, concentrations of cadmium, lead, and zinc were higher at PS-22 while the concentration of copper was lower at PS-21. Antimony, SVOCs, and Aroclors[®] were not analyzed at MW-15. These data suggest that contamination in the vicinity of MW-15 does not affect the Diamond Shamrock/Henkel property; however, the data are of limited use in evaluating whether the contamination affects the Randolph Property.

4.2 Groundwater

This section summarizes the SoPC concentrations in groundwater samples collected from the 15 monitoring wells located in the developed and undeveloped filled areas of the Site. Ten metals (arsenic, cadmium, iron, lead, manganese, mercury, nickel, selenium, sodium, and thallium), five VOCs (benzene, chlorobenzene, 1,2-dichloroethene isomers, toluene, and xylenes), and one SVOC (DEHP) were identified as SoPCs (see Section 1.4). Of these, selenium exceeded only surface water criteria, not groundwater criteria values. Tables 4-4a, b, c, and d provide summaries of chemical analysis results for these SoPCs, and the SoPCs identified for seeps and surface water. Complete chemical analysis results with screening against GWQS, SWQS, and MCLs for the groundwater samples, including the 1991 NJDEP data, are presented in Appendix B1, Tables B1-7a through B1-7o. The screening against SWQS was only conducted for perimeter wells: MW-1, MW-3, MW-4, MW-5, MW-6, MW-8, MW-12, and MW-15.

4.2.1 Mercury

In Phase I, mercury concentrations in the 12 monitoring well samples ranged from 0.5 to 8.2 $\mu\text{g/L}$ (Figure 4-13). Seven of the 12 samples had mercury concentrations below the IDL (0.2 $\mu\text{g/L}$). The only Phase I sample with a concentration greater than the GWQS and the MCL was collected from monitoring well MW-7. Except at MW-7 and MW-5, all Phase I samples collected from monitoring wells in the undeveloped filled area of the

Site had mercury concentrations below IDLs. The SWQS for mercury ($0.144\text{ }\mu\text{g/L}$) was below the IDL ($0.2\text{ }\mu\text{g/L}$) for this round of sampling.

In Phase IA groundwater samples collected in 1999, a more sensitive chemical analysis method for mercury was used and mercury concentrations in the 15 monitoring wells ranged from 0.0108 to $54.2\text{ }\mu\text{g/L}$ (Figure 4-13). Mercury concentrations in three wells (MW-7, MW-13, and MW-15) exceeded the GWQS and the MCL. In the perimeter wells, the SWQS was exceeded in five wells (MW-3, MW-5, MW-8, MW-12, and MW-15). The sample from MW-15, which had the highest mercury concentration, had a turbidity value much higher than the other Phase IA samples (see water quality parameters in Appendix F). The other perimeter wells had mercury concentrations ranging from 0.0108 to $1.23\text{ }\mu\text{g/L}$.

Wells MW-7, MW-13, and MW-15 were sampled again in June 2000, and all 15 wells were sampled in September 2002 as part of the Phase IA SFI. Both filtered and unfiltered samples were collected, again using the low-flow collection method. Mercury concentrations in groundwater from wells MW-7, MW-13, and MW-15 did not exceed the GWQS and MCL in filtered samples (i.e., dissolved mercury), but remained above the GWQS and MCL in unfiltered samples during one or both sampling events. Mercury in the sample from well MW-9 exceeded the GWQS and MCL in the unfiltered sample only. Mercury concentrations in unfiltered samples from wells MW-7 and MW-15 were one to two orders of magnitude lower than concentrations detected in 1999, and two to three orders of magnitude lower than in unfiltered samples. The turbidity values for MW-15 declined from around 60 NTU in the Phase IA sample to 8 NTU in the supplemental sample. Mercury concentrations in well MW-13 remained generally similar to concentrations detected in 1999. The SWQS in perimeter wells was exceeded in MW-15 in 2000 and in MW-8 and MW-15 (unfiltered sample only) in 2002.

Monitoring wells were installed in 1990 and sampled by NJDEP in 1991 (NJDEP 1993a). Groundwater chemical analysis results were reported for both total and dissolved (field filtered) metal concentrations (Figure 4-13). The concentrations of dissolved metals were generally comparable to the results of the Phase I and IA investigation, ranging from 0.32 to $18.7\text{ }\mu\text{g/L}$ in the three samples with concentrations above detection limits. The SWQS was exceeded only in MW-3, although the IDL was likely above the SWQS for this sampling effort.

Methylmercury concentrations in groundwater samples from Phase I ranged from $0.00014\text{ }\mu\text{g/L}$ (MW-10) to $0.02\text{ }\mu\text{g/L}$ (MW-2) and in Phase IA ranged from $0.00012\text{ }\mu\text{g/L}$ (MW-14) to $0.0327\text{ }\mu\text{g/L}$ (MW-3) (Figure 4-14). MW-10 had the second lowest methylmercury concentration ($0.00019\text{ }\mu\text{g/L}$) in Phase IA. Methylmercury was not measured for the groundwater samples collected by NJDEP in 1991 or in the supplemental Phase IA sampling event.

4.2.2 Other Metals

Distributions of the metal SoPCs, other than mercury, in groundwater samples collected from the monitoring wells are as follows. The distribution of sodium is also discussed below.

- **Antimony**—Antimony was not detected in Phase I groundwater samples (detection limit of $3.4 \mu\text{g/L}$) and was not analyzed in Phase IA groundwater samples. In the NJDEP groundwater data from 1991, the antimony concentration at MW-8 ($12 \mu\text{g/L}$) in the filtered samples exceeded the MCL and equaled the SWQS. For the unfiltered NJDEP samples, the antimony concentration at MW-7 ($54 \mu\text{g/L}$) exceeded the MCL and the GWQS, and the antimony concentration at MW-12 ($14 \mu\text{g/L}$) exceeded the MCL and the SWQS. MW-7 is not a perimeter well and was not screened against the SWQS. Screening criteria were not exceeded in any other samples.
- **Arsenic**—Arsenic concentrations in groundwater samples exceeded the GWQS and MCL at MW-6 (13.0 and $14.6 \mu\text{g/L}$) in Phase I; MW-13 ($21.4 \mu\text{g/L}$) and MW-14 ($17.1 \mu\text{g/L}$) in Phase IA; and MW-6 ($12.2 \mu\text{g/L}$), MW-13 ($41.5 \mu\text{g/L}$), and MW-15 ($10.9 \mu\text{g/L}$) in the Phase IA SFI in 2002 (Figure 4-15). Arsenic was detected at only one other well, MW-11 (2.6 and $6.4 \mu\text{g/L}$), in both Phases I and IA. Only one NJDEP groundwater sample from 1991 (MW-6, $23 \mu\text{g/L}$, unfiltered) exceeded the GWQS and MCL. The SWQS was exceeded in the following perimeter well samples: MW-6 in the Phase I investigation; MW-6 and MW-15 in the Phase IA SFI in 2002; filtered samples from MW-3, MW-5, MW-6, MW-8, and MW-12 in the NJDEP investigation; and unfiltered samples from MW-1, MW-3, MW-4, MW-5, MW-6, MW-8, and MW-12 in the NJDEP investigation.
- **Cadmium**—Cadmium concentrations in groundwater exceeded the GWQS and MCL at MW-5 ($5.7 \mu\text{g/L}$) in Phase IA and did not exceed the SWQS at any of the Site perimeter monitoring wells (Figure 4-16). In Phase I, cadmium was detected in only 2 of the 12 wells sampled, while in Phase IA cadmium was detected in 11 of the 15 wells sampled. In the NJDEP data from 1991, cadmium concentrations exceeded the GWQS and MCL in two of the unfiltered samples, MW-1 ($6 \mu\text{g/L}$) and MW-7 ($7 \mu\text{g/L}$).
- **Iron**—Iron concentrations in groundwater samples exceeded the GWQS at all wells except MW-9 in Phase I, at all wells except MW-9 and MW-10 in Phase IA, and at all wells except the filtered sample from MW-10 in the NJDEP data (Figure 4-17). The highest

concentrations of iron in groundwater were measured at MW-8 in Phases I and IA, and at MW-2 in the NJDEP data. There is no SWQS or MCL for iron.

- **Lead**—Lead concentrations in groundwater exceeded the GWQS at MW-15 (13.9 $\mu\text{g/L}$) and exceeded the SWQS at all perimeter wells except MW-1, MW-3, MW-4, and MW-5 during Phase IA (Figure 4-18). The MCL was not exceeded in any sample. It should be noted that when MW-15 was sampled and analyzed for mercury only, during the Phase IA supplemental study, the mercury concentrations and sample turbidity, were much lower than during Phase IA. It is likely, therefore, that the lead concentration would also have been much lower in the supplemental Phase IA sample. The only concentration value for lead in groundwater reported by the NJDEP from the 1991 sampling was 2 $\mu\text{g/L}$ in MW-6, a value below the GWQS, the SWQS, and the MCL.
- **Manganese**—Manganese concentrations in groundwater samples exceeded the GWQS in all 12 monitoring wells in Phase I, all wells except MW-9 in Phase IA, all wells in the Phase IA SFI in 2002, and all wells for which data was reported from the 1991 NJDEP sampling (Figure 4-19). The highest manganese concentrations in groundwater were from MW-6 in Phase I (3,840 $\mu\text{g/L}$), MW-14 in Phase IA (6,580 $\mu\text{g/L}$), MW-8 in the Phase IA SFI in 2002 (4,180 $\mu\text{g/L}$), and MW-9 in the NJDEP data (8,100 and 7,930 $\mu\text{g/L}$ in unfiltered and filtered samples, respectively). The lowest manganese concentration in both Phases I and IA was from MW-9. The second highest manganese concentration in Phase IA was in the sample from MW-6 (4,210 $\mu\text{g/L}$). There is no SWQS or MCL for manganese.
- **Nickel**—Nickel concentrations in the Phase I groundwater sample from MW-6 (116 $\mu\text{g/L}$) and the 1991 unfiltered NJDEP sample from MW-7 (163 $\mu\text{g/L}$) exceeded the GWQS (Figure 4-20). There is no MCL for nickel.
- **Selenium**—Selenium concentrations in Phase IA groundwater samples exceeded the SWQS in only one sample MW-3 (13.4 $\mu\text{g/L}$) (Figure 4-21). In the 1991 filtered NJDEP samples, the selenium concentration in wells MW-1, MW-2, MW-4, MW-6, and MW-7 were reported as 20 $\mu\text{g/L}$ and the concentration in MW-8 was reported as 30 $\mu\text{g/L}$, all of which exceed the SWQS. There were no other SWQS or MCL exceedances in water samples. No values were reported for the 1991 unfiltered NJDEP samples. There is no GWQS for selenium.
- **Sodium**—Sodium concentrations in Phase I samples exceeded the GWQS in five of the seven perimeter wells and two interior wells. Sodium was not measured in Phase IA (Figure 4-22). NJDEP

measured sodium concentrations in filtered samples that exceeded the GWQS in 7 wells and unfiltered samples in 8 wells. There is no MCL for sodium.

- **Thallium**—Thallium concentrations in groundwater samples exceeded the GWQS and MCL in Phase IA at MW-2 (14.7 and 12.3 $\mu\text{g/L}$) (Figure 4-23). In Phase I, thallium in MW-2 was originally reported by the laboratory at 10.3 $\mu\text{g/L}$, but was qualified as undetected during the data validation process. There were no other GWQS exceedances. Thallium concentrations exceeded the SWQS and the MCL at MW-3 (5.0 $\mu\text{g/L}$) and MW-6 (7.1 $\mu\text{g/L}$) in Phase I and at MW-5 (5.5 $\mu\text{g/L}$) in Phase IA. Thallium was reported in only one well from the 1991 NJDEP sampling, the unfiltered sample from MW-1 (3 $\mu\text{g/L}$). There were no exceedances of the GWQS, MCL, or SWQS in the Phase IA SFI in 2002.

4.2.3 Organic Compounds

Distributions of the organic SoPCs in groundwater are described below.

- **Benzene**—Benzene concentrations in groundwater exceeded the GWQS and MCL at sample locations MW-2 (140 $\mu\text{g/L}$) and MW-7 (18 $\mu\text{g/L}$) in Phase I and at locations MW-2, MW7, MW13, and MW-15 in Phase IA (Figure 4-24). The GWQS was also exceeded in Phase IA at locations MW-5 and MW-8. The SWQS was exceeded in Phase IA samples at MW-5, MW-8, and MW-15. Benzene was below the IDL (10 $\mu\text{g/L}$) at the remaining 10 sample locations in Phase I. In Phase IA, a more sensitive chemical analysis method was selected to produce an IDL of 1 $\mu\text{g/L}$. Benzene concentrations were not reported in the 1991 NJDEP groundwater data.
- **Chlorobenzene**—Chlorobenzene concentrations in groundwater samples exceeded the GWQS in both Phases I and IA at wells MW-1 (15 $\mu\text{g/L}$ and 28 $\mu\text{g/L}$) and MW-5 (5 $\mu\text{g/L}$ and 15 $\mu\text{g/L}$) (Figure 4-25). There were no other GWQS exceedances and no MCL exceedances. The Phase IA sample at MW-1 exceeded the SWQS.
- **Toluene**—Toluene concentrations in groundwater samples exceeded the GWQS and the MCL at MW-2 (1,700 $\mu\text{g/L}$) in Phase I (Figure 4-26). The toluene concentration at MW-2 in Phase IA was detectable, but below the GWQS and the MCL. Concentrations in samples from all other Phases I and IA samples were below IDLs (10 $\mu\text{g/L}$ in Phase I and 5 $\mu\text{g/L}$ in Phase IA) for toluene. There were no other GWQS or MCL exceedances.

- **Xylenes**—Xylene isomers (total) concentrations exceeded the GWQS at MW-2 in each of Phase I (390 $\mu\text{g/L}$), Phase IA (73 $\mu\text{g/L}$), and in the NJDEP data from 1991 (47 $\mu\text{g/L}$) (Figure 4-27). Concentrations in Phase I and IA samples from all other wells were below the IDLs (10 $\mu\text{g/L}$ in Phase I and 5 $\mu\text{g/L}$ in Phase IA). Concentrations for other wells were not reported for the 1991 NJDEP sampling. There were no MCL exceedances for xylenes.
- **Other Organic Compounds**—Only one groundwater sample (MW-6) from Phase I and IA had detectable DEHP (6 $\mu\text{g/L}$). This value did not exceed the GWQS and MCL (Figure 4-28), but did exceed the SWQS. 1,2-Dichloroethene isomers were detected in only two Phase I groundwater samples MW-8 (2 $\mu\text{g/L}$) and MW-9 (45 $\mu\text{g/L}$) (Figure 4-29). Only the latter exceeds the GWQS. There is no MCL and SWQS for 1,2-dichloroethene isomers and it was not analyzed in Phase IA. 1,1,2,2-Tetrachloroethane was not detected in any Phase I groundwater samples (Figure 4-30). However, all of the samples have detection limits greater than the GWQS and eight of the samples have detection limits greater than the SWQS. There is no MCL for 1,1,2,2-tetrachloroethane and it was not analyzed in Phase IA.

4.3 Leachate/Seeps

This section summarizes the occurrence of SoPCs in leachate/seep samples collected from five locations. In Phase I, two samples were collected along the stream banks of the Diamond Shamrock/Henkel Ditch (north) (SE-01 and SE-02), and three samples were collected along the stream banks of Berry's Creek (SE-03, SE-04, and SE-06). In Phase IA, samples were collected as close to the Phase I locations as possible, which for seep SE-04 was the same location (Figure 2-1d). Phase I seep samples for metals analysis were filtered in the laboratory, while Phase IA samples were filtered in the field. The results reported for unfiltered samples will be referred to as total metal concentrations. The results reported for filtered samples are also referred to in the text as the dissolved metal concentrations. It should be noted that this concentration represents the dissolved fraction and material (colloidal and particulate) small enough to pass through the filter. This terminology applies to filtered and unfiltered surface water samples also. In Phase IA, the sample volume requirement was smaller than in Phase I, and, therefore, more careful sampling techniques could be used. Nevertheless, only the dissolved concentrations are used for comparison to criteria values, since even careful sampling techniques introduce some particulates into the seep samples that are not likely being carried by the seep.

Six metals (arsenic, cadmium, iron, manganese, mercury, and sodium) and one organic compound (DEHP) were identified as SoPCs (see Section 1.4). Tables 4-5a and b provide summaries of chemical analysis results for seep SoPCs, for Phase I and Phase IA

samples, respectively. Complete chemical analysis results for leachate/seep samples are presented in Appendix B1, Tables B1-8a, b, c, and d.

4.3.1 Mercury

In Phase I, dissolved mercury concentrations in seep samples collected from the stream banks of the Diamond Shamrock/Henkel Ditch (north) were all below the IDL ($0.2 \mu\text{g/L}$) (Figure 4-13). With the more sensitive chemical analysis method used in Phase IA, mercury was detected in seep samples, though none of the dissolved concentrations exceeded the SWQS. Phase I dissolved mercury concentrations in seep samples from the stream banks of Berry's Creek were $0.26 \mu\text{g/L}$ at SE-04 and $1.8 \mu\text{g/L}$ at SE-06 (the sample from SE-03 was $<0.2 \mu\text{g/L}$). Phase IA concentrations at the comparable location were much lower, ranging from 0.0118 to $0.0667 \mu\text{g/L}$ for the three samples along Berry's Creek.

Total (unfiltered sample) mercury concentrations were greater than dissolved mercury in seep samples (ranging from 2.1 to $104 \mu\text{g/L}$ in Phase I and 0.0079 to $5.26 \mu\text{g/L}$ in Phase IA). The sample total suspended solids (TSS) concentrations ranged from 140 to 505 mg/L in Phase I and 23.5 to 94.6 mg/L in Phase IA. Too few data are available to develop a correlation between the concentration of total mercury and TSS; however, the highest total mercury concentration is associated with the highest TSS content in both Phases I and IA.

Dissolved methylmercury concentrations from the two samples collected from the banks of the Diamond Shamrock/Henkel Ditch (north) were $0.00011 \mu\text{g/L}$ for location SE-1 and $0.00031 \mu\text{g/L}$ for SE-02 in Phase I and $0.00019 \mu\text{g/L}$ and $0.00023 \mu\text{g/L}$ for the comparable locations in Phase IA (Figure 4-14). Dissolved methylmercury concentrations in seeps from the banks of Berry's Creek ranged from 0.00028 to $0.0022 \mu\text{g/L}$ in Phase I and 0.00188 to $0.0023 \mu\text{g/L}$ in Phase IA. Total methylmercury concentrations in seep samples were substantially higher than dissolved methylmercury concentrations, ranging from 0.00074 to $0.0331 \mu\text{g/L}$ in Phase I and 0.00084 to $0.02914 \mu\text{g/L}$ in Phase IA. As was found for total mercury, the highest concentration of methylmercury in unfiltered samples was in the sample with the highest TSS concentration.

4.3.2 Other Metals

The following distributions were found for metals other than mercury in seep samples collected from five sample locations:

- **Arsenic**—Arsenic concentrations in filtered samples exceeded the SWQS at SE-01 and SE-06 in Phase I. In the unfiltered samples, arsenic concentrations exceeded the SWQS at the two locations above

and SE-03, and exceeded the GWQS at SE-01 and SE-03. The highest total arsenic concentration was reported in the sample with the highest TSS concentration. In Phase IA, arsenic was not detected in any of the samples.

- **Cadmium**—The dissolved cadmium concentration was above the GWQS at one Phase I sample location (5.6 $\mu\text{g/L}$ at SE-02); the other four seep samples had dissolved cadmium concentrations below IDLs. Cadmium was not detected in any filtered Phase IA seep samples. Phase I cadmium concentrations in the unfiltered samples ranged from 2 to 23.3 $\mu\text{g/L}$, while in Phase IA they ranged from below the IDL (0.62 $\mu\text{g/L}$) to 3.7 $\mu\text{g/L}$. The highest total cadmium concentration was reported at the same location (SE-01) that had the highest TSS content (505 mg/L) in Phase I, while TSS was not analyzed at the location with the highest total cadmium concentration in Phase IA. In Phase I, the sample with the highest dissolved cadmium concentration (5.6 $\mu\text{g/L}$) had only a marginally higher total cadmium concentration (6.9 $\mu\text{g/L}$; TSS of 203 mg/L).
- **Iron**—Dissolved iron concentrations exceeded the GWQS at SE-04 (524 $\mu\text{g/L}$) in Phase I and at SE-01A (1,500 $\mu\text{g/L}$), SE-04 (2,310 $\mu\text{g/L}$), and SE-04A (3,370 $\mu\text{g/L}$) in Phase IA. The dissolved concentration at location SE-01 was below the IDL (9.4 $\mu\text{g/L}$) in Phase I, and the dissolved concentration at SE-03A was reported by the laboratory as 32.8 $\mu\text{g/L}$, but qualified as not detected during the data validation process. The concentrations of total iron were substantially higher, ranging from 1,430 to 23,600 $\mu\text{g/L}$ in Phase I and 2,230 to 8,430 $\mu\text{g/L}$ in Phase IA. In Phase I, sample location SE-01 had the highest total iron concentration and also had the highest TSS concentration (505 mg/L). In Phase IA, the seep sample with the highest total iron concentration did not have the highest TSS concentration.
- **Manganese**—Dissolved manganese concentrations were above the GWQS for all seep samples in both Phases I and IA. The dissolved manganese concentrations ranged from 200 to 1,660 $\mu\text{g/L}$ in Phase I and from 447 to 1,370 $\mu\text{g/L}$ in Phase IA, while total manganese concentrations ranged from 295 to 1,770 $\mu\text{g/L}$ in Phase I and from 502 to 1,480 $\mu\text{g/L}$ in Phase IA. The difference between the dissolved and total concentration was not substantial, indicating that manganese in seep samples occurs predominantly in the dissolved phase.
- **Sodium**—Dissolved sodium concentrations exceeded the GWQS at all Phase I seep locations. As with manganese, the differences between total and dissolved concentrations were small, indicating that sodium occurs predominantly in the dissolved phase. Since the Phase I results indicated that sodium was not originating on Site, it was not measured in Phase IA.

4.3.3 Organic Compounds

Only one organic compound was detected in seep samples: DEHP. Concentrations did not exceed the GWQS but did exceed the SWQS in two seeps (SE-02 at 2 $\mu\text{g/L}$ and SE-03 at 4 $\mu\text{g/L}$) in 1997. In some cases, the IDLs for other organic compounds were higher than the GWQS and SWQS.

4.4 Surface Water

This section summarizes the concentrations of SoPCs in surface waters collected from four locations in Berry's Creek, three locations in the Diamond Shamrock/Henkel Ditch (north), and two locations in the onsite basin during Phase I and three locations in the West Ditch during Phase IA. One surface water sample was collected during three tidal stages (low, mid, and high) at each location in Berry's Creek. Surface waters from the three locations in the Diamond Shamrock/Henkel Ditch (north) were collected as close to high tide as possible. Samples designated for dissolved metals analyses were filtered in the laboratory. In Phase IA, only whole water (unfiltered) samples were analyzed.

In OU1, two metals (lead and mercury) were identified as surface water SoPCs, while in OU2, four metals (arsenic, lead, mercury, and thallium), one VOC (1,1,2,2-tetrachloroethane), and one SVOC (DEHP) were identified as SoPCs for surface water (see Section 1.4). Tables 4-6a, b, and c provide summaries of chemical analysis results for SoPCs in surface water for the onsite basin and West Ditch in OU1 and for OU2. Complete chemical analysis results for surface water samples are presented in Appendix B1, Tables B1-9a, B1-9b, B2-1a, and B2-1b.

4.4.1 Mercury

4.4.1.1 OU1

The OU1 surface water samples were collected from the onsite basin (Phase I) and the West Ditch (Phase IA) (Figure 4-13). Mercury concentrations in all of the unfiltered samples exceeded the SWQS value.

For the onsite basin, the mercury concentration in SW-08 (17.6 $\mu\text{g/L}$) was nearly three times as high as the concentration in SW-09 (5.8 $\mu\text{g/L}$), while the TSS concentrations in these two samples were identical, at 6 mg/L. Mercury concentrations in the filtered samples from the onsite basin were below the IDL (0.2 $\mu\text{g/L}$), though the IDL was greater than the SWQS value. The IDL is, however, an order of magnitude less than the

surface water (acute) criterion ($2.1 \mu\text{g/L}$) for dissolved mercury. Filtered samples were not analyzed in Phase IA.

Mercury concentrations in all three of the Phase IA unfiltered samples from the West Ditch exceeded the SWQS. The concentrations at the three locations were similar to each other, varying only from 0.402 to $0.738 \mu\text{g/L}$.

For both the filtered and unfiltered samples, methylmercury concentrations in the two samples from the onsite basin were similar to each other (0.00218 and $0.00233 \mu\text{g/L}$ for the unfiltered samples and 0.00085 and $0.00098 \mu\text{g/L}$ for the filtered). Methylmercury concentrations in the West Ditch samples were lower than for the onsite basin, ranging from 0.00114 to $0.00277 \mu\text{g/L}$. Methylmercury concentrations as a percentage of total mercury were much lower in the onsite basin than in the West Ditch, while the percentages in the onsite basin were generally comparable to those in OU2 surface waters (Figure 4-14).

4.4.1.2 OU2

In OU2, total mercury concentrations in unfiltered samples ranged from 0.74 to $15.6 \mu\text{g/L}$. The highest concentrations in Berry's Creek were from the low tide samples at locations SW-01 ($5.7 \mu\text{g/L}$), SW-02 ($15.6 \mu\text{g/L}$), and SW-03 ($1.3 \mu\text{g/L}$). The TSS concentrations in all samples from these three stations were all within the range of 11 to 16 mg/L , except the low tide sample from SW-01, which had a TSS concentration of 33 mg/L . The second highest concentration overall in OU2 was from SW-05 ($8.4 \mu\text{g/L}$), at the upstream end of the Diamond Shamrock/Henkel Ditch (north), which had the highest TSS concentration of all OU2 surface water samples, 84 mg/L .

For the filtered samples, only two surface water locations had dissolved mercury concentrations above the IDL ($0.2 \mu\text{g/L}$), which is also above the SWQS (Figure 4-13). Both samples were collected during low tide at locations in Berry's Creek ($0.24 \mu\text{g/L}$ at SW-02, and $0.2 \mu\text{g/L}$ at SW-03).

Methylmercury concentrations in unfiltered samples ranged from 0.00058 to $0.00464 \mu\text{g/L}$ (Figure 4-14). Total methylmercury concentrations in Berry's Creek samples were higher in samples collected during low tide (0.00105 to $0.00287 \mu\text{g/L}$) than in those collected during high and mid-tide (0.00058 to $0.00095 \mu\text{g/L}$). The sample with the largest difference between the dissolved and total methylmercury concentrations was collected at sample location SW-05, which also had the highest TSS content (84 mg/L).

Dissolved methylmercury concentrations in Berry's Creek samples ranged from 0.00008 to $0.00047 \mu\text{g/L}$, while the concentrations from the Diamond Shamrock/Henkel Ditch (north) samples were lower, ranging from 0.00019 to $0.00027 \mu\text{g/L}$. In Berry's Creek, methylmercury as a percentage of mercury varied widely, from 0.00067 to 0.1 percent, while the range in the Diamond Shamrock/Henkel Ditch (north) was only from 0.0552 to 0.0693 percent.

4.4.2 Other Metals

The following distributions were found for lead in OU1 surface waters and for arsenic, lead, and thallium in OU2 surface waters.

4.4.2.1 OU1

- **Lead**—Lead concentrations exceeded the SWQS only at stations SW-11 (19 $\mu\text{g/L}$) and SW-12 (5.9 $\mu\text{g/L}$) in the West Ditch.

4.4.2.2 OU2

- **Arsenic**—Arsenic concentrations in unfiltered samples from SW-04 (2.9 $\mu\text{g/L}$ at high tide and 3.4 $\mu\text{g/L}$ at low tide) and SW-05 (14.2 $\mu\text{g/L}$) exceeded the SWQS. Arsenic was not detected in any of the filtered OU2 surface water samples.
- **Lead**—Lead concentrations in unfiltered samples exceeded the SWQS at SW-01 low tide (8.6 $\mu\text{g/L}$), SW-02 low tide (9.6 $\mu\text{g/L}$), SW-04 low tide (8.1 $\mu\text{g/L}$), and SW-05 (119 $\mu\text{g/L}$). Lead was not detected in any filtered OU2 surface water samples.
- **Thallium**—Thallium concentrations in unfiltered samples exceeded the SWQS at SW-04 mid-tide (6.7 $\mu\text{g/L}$) and at SW-05 (9.5 $\mu\text{g/L}$). Thallium was detected in only one filtered OU2 surface water sample, from SW-05 (5.3 $\mu\text{g/L}$). The chemical analysis laboratory originally reported concentrations from eight other surface water samples at values above the SWQS, but these values were restated as not detected during the data validation process.

4.4.3 Organic Compounds

Distributions of the two organic SoPCs identified in OU2 surface water are described below.

- **1,1,2,2-Tetrachloroethane**—1,1,2,2-Tetrachloroethane was detected in the sample from only one station, SW-02 low tide (3 $\mu\text{g/L}$), a value

that exceeds the SWQS. The IDL (10 $\mu\text{g/L}$), however, was above the SWQS for all the other samples.

- **Bis[2-ethylhexyl]phthalate**—DEHP concentrations exceeded the SWQS only at SW-04 high tide (4 $\mu\text{g/L}$). The concentration at two stations SW-02 high tide (2 $\mu\text{g/L}$) and SW-06 (2 $\mu\text{g/L}$) equaled the SWQS. DEHP was detected at two other stations (SW-01 and SW-03 mid-tide). At the remaining stations, DEHP was below the IDL of 10 $\mu\text{g/L}$, a value above the SWQS.

4.5 Sediment

Surface sediment was collected from each surface water location. Surface sediment is defined as the upper 0 to 15 cm of sediment. A second grab sample was collected from the upper 0 to 2 cm at each Phase I sample location and analyzed only for mercury. Nine metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc), sixteen SVOCs (acenaphthene, acenaphthylene, anthracene, benz[a]anthracene, benzo[a]pyrene, benzo[ghi]perylene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, fluoranthene, fluorene, indeno[1,2,3-cd]pyrene, 2-methylnaphthalene, naphthalene, phenanthrene, and pyrene), and two PCB Aroclor[®] mixtures (1248 and 1260) were identified as SoPCs (see Section 1.4). These 16 SVOCs are all polycyclic aromatic hydrocarbons (PAHs). Tables 4-7a, b, c and d provide summaries of chemical analysis results for SoPCs in sediments from OU1, OU2 streambeds, and OU2 marsh soils. Complete chemical analysis results for sediment samples are presented in Appendix B1, Tables B1-10a, B1-10b, B2-2, and B2-3.

4.5.1 Mercury

4.5.1.1 OU1

Mercury concentrations in the 0- to 15-cm interval for OU1 sediments ranged from 19 to 155 mg/kg in the West Ditch and from 1,280 to 1,290 mg/kg in the onsite basin (Figure 4-1). Concentrations in the 0- to 2-cm interval in the onsite basin were somewhat lower, at 856 and 1,180 mg/kg.

4.5.1.2 OU2 Streambed Sediment

Mercury concentrations for surface sediment collected from the 0- to 15-cm sampling interval in Berry's Creek ranged from less than the IDL (0.16 mg/kg) at SW-04 to 70 mg/kg at SD-02 and SD-03. Concentrations in the Diamond Shamrock/Henkel Ditch (north) ranged only from 59.2 to 69.6 mg/kg.

A second sediment sample was collected from the 0- to 2-cm depth at each sample location to evaluate the mercury concentration in the biologically-active sediment. Mercury concentrations in these 2-cm intervals were similar to concentrations in the 15-cm intervals at most locations. For the Diamond Shamrock/Henkel Ditch (north), the largest difference between mercury concentrations in the 0- to 2-cm interval and the 0- to 15-cm interval was at SD-06, where the concentrations were 97.8 and 67.3 mg/kg, respectively. In Berry's Creek, the largest discrepancy between the two sampling intervals occurred at location SD-02. The mercury concentration increased from 69.6 mg/kg in the 0- to 15-cm sample interval to 11,100 mg/kg in the 0- to 2-cm sample interval. A decrease was observed at sample location SD-01 (33.8 to 31.3 mg/kg) and modest increases were observed at locations SD-03 (70 to 223 mg/kg) and SD-04 (<0.16 to 0.89 mg/kg).

Methylmercury concentrations in surface sediments collected from the 0- to 15-cm sample intervals ranged from 0.00038 to 0.00975 mg/kg in Berry's Creek sediments and from 0.012 to 0.02 mg/kg in Diamond Shamrock/Henkel Ditch (north) sediments (Figure 4-2).

4.5.1.3 OU2 Marsh Soils

Mercury concentrations in marsh soils from the 0-2 ft interval ranged from 25.1 to 1,090 mg/kg, with a mean of 170 mg/kg (Table 4-7d). The lowest and highest concentrations in this area were measured in soils from adjacent sample locations (SS-36 and SS-37, respectively) (Figure 4-1).

Methylmercury concentrations were measured in all 19 samples collected from the marsh area (Figure 4-2). Concentrations ranged over nearly two orders of magnitude, from 0.004 to 0.233 mg/kg. Methylmercury as a percentage of total mercury ranged from 0.0052 to 0.14 percent.

4.5.2 Other Metals

The following distributions were found for metals other than mercury in surface sediment from the 0- to 15-cm interval in streambed and basin sediments and from the 0- to 2-ft interval in the marsh soils:

4.5.2.1 OU1

- **Arsenic**—Arsenic concentrations in sediment exceeded the screening criterion only at station SD-09 (8.8 mg/kg) (Figure 4-3)
- **Cadmium**—Cadmium concentrations in sediment exceeded the screening criterion at all five stations (Figure 4-10)
- **Chromium**—Chromium concentrations in sediment exceeded the screening criterion at all five stations (Figure 4-31)
- **Copper**—Copper concentrations in sediment exceeded the screening criterion at all five stations (Figure 4-4)
- **Lead**—Lead concentrations in sediment exceeded the screening criterion at all five stations (Figure 4-5)
- **Nickel**—Nickel concentrations in sediment exceeded the screening criterion at four of the five stations, all except SD-08 (Figure 4-11)
- **Silver**—Silver concentrations in sediment exceeded the screening criterion at both stations in the onsite basin and SD-12 in the West Ditch (Figure 4-32)
- **Zinc**—Zinc concentrations in sediment exceeded the screening criterion at all five stations (Figure 4-7).

4.5.2.2 OU2 Streambed Sediments

- **Arsenic**—Arsenic concentrations exceeded the screening criterion in all OU2 sediment samples. Concentrations at sample locations in the Diamond Shamrock/Henkel Ditch (north) ranged from 16.8 to 24.6 mg/kg, while the concentrations in surface sediment from Berry's Creek were somewhat lower, ranging from 6.6 to 9.1 mg/kg (Figure 4-3).
- **Cadmium**—Cadmium concentrations exceeded the screening criterion in all OU2 sediment samples except at SD-04, where the concentrations was less than the IDL (0.07 mg/kg). Concentrations at sample locations in the Diamond Shamrock/Henkel Ditch (north) ranged from 12.1 to 17.1 mg/kg. Concentrations in surface sediment from Berry's Creek varied over a similar range, from 6.8 to 13.8 mg/kg (Figure 4-10).
- **Chromium**—Chromium concentrations exceeded the screening criterion in all OU2 sediment samples except at SD-04.

Concentrations at sample locations in the Diamond Shamrock/Henkel Ditch (north) ranged from 294 to 930 mg/kg while concentrations in surface sediment from Berry's Creek were all lower, ranging from 18 to 265 mg/kg (Figure 4-31).

- **Copper**—Copper concentrations exceeded the screening criterion in all OU2 sediment samples except at SD-04. Concentrations at sample locations in the Diamond Shamrock/Henkel Ditch (north) ranged from 190 to 287 mg/kg, while concentrations in surface sediment from Berry's Creek were all lower, ranging from 11.1 to 161 mg/kg (Figure 4-4).
- **Lead**—Lead concentrations exceeded the screening criterion in all OU2 sediment samples except at SD-04. Concentrations at sample locations in the Diamond Shamrock/Henkel Ditch (north) ranged from 177 to 232 mg/kg, while concentrations in surface sediment from Berry's Creek were all lower, ranging from 20.5 to 176 mg/kg (Figure 4-5).
- **Nickel**—Nickel concentrations exceeded the screening criterion in all OU2 sediment samples except at SD-04. Concentrations at sample locations in the Diamond Shamrock/Henkel Ditch (north) ranged from 37.8 to 66.4 mg/kg, while concentrations in surface sediment from Berry's Creek were all lower, ranging from 14.8 to 31.2 mg/kg (Figure 4-11).
- **Silver**—Silver concentrations exceeded the screening criterion in all OU2 sediment samples except at SD-04. Concentrations at sample locations in the Diamond Shamrock/Henkel Ditch (north) ranged from 2.3 to 4.8 mg/kg. Concentrations in surface sediment from Berry's Creek varied over a similar range, from 1.4 to 3.6 mg/kg (Figure 4-32).
- **Zinc**—Zinc concentrations exceeded the screening criterion in all OU2 sediment samples except at SD-04. Concentrations at sample locations in the Diamond Shamrock/Henkel Ditch (north) ranged from 2,640 to 7,300 mg/kg, while concentrations in surface sediment from Berry's Creek were all lower, ranging from 56.1 to 792 mg/kg (Figure 4-7).

4.5.2.3 OU2 Marsh Soils

- **Arsenic**—Arsenic concentrations exceeded the screening criteria value in all OU2 marsh soil samples except SS-36 (Figure 4-3)
- **Cadmium**—Cadmium concentrations exceeded the screening criteria value in all OU2 marsh soil samples (Figure 4-10)

- **Chromium**—Chromium concentrations exceeded the screening criteria value in all OU2 marsh soil samples (Figure 4-31)
- **Copper**—Copper concentrations exceeded the screening criteria value in all OU2 marsh soil samples (Figure 4-4)
- **Lead**—Lead concentrations exceeded the screening criteria value in all OU2 marsh soil samples (Figure 4-5)
- **Nickel**—Nickel concentrations exceeded the screening criteria value in all OU2 marsh soil samples (Figure 4-11)
- **Silver**—Silver concentrations exceeded the screening criteria value in all but 2 of the 19 OU2 marsh soil samples (Figure 4-32)
- **Zinc**—Zinc concentrations exceeded the screening criteria value in all OU2 marsh soil samples (Figure 4-7).

4.5.3 Organic Compounds

PAHs above sediment screening criteria values are widely distributed throughout the sediment samples collected during this investigation, though screening criteria exceedances occurred less frequently than for metals.

In OU1, station SD-10 generally had the highest PAH concentrations in the West Ditch, while concentrations in SD-11 and SD-12 were generally similar to each other. The sample collected from the eastern side of the onsite basin (SD-09) had generally higher PAH concentrations than the sample from the western side of the basin (SD-08).

In OU2 streambed sediments, sample location SD-05 had the highest reported total concentration of these 16 PAHs, though SD-01 had elevated IDLs that were higher than the reported concentration at SD-05. Total PAH concentrations decreased with greater distance downstream from SD-05 along the Diamond Shamrock/Henkel Ditch (north).

In OU2 marsh soils, the PAHs with the highest numbers of criteria exceedances are benz[a]anthracene, benzo[a]pyrene, benzo[ghi]perylene, chrysene, indeno[1,2,3-cd]pyrene, and pyrene.

4.5.4 PCB Aroclors[®]

4.5.4.1 OU1

PCB Aroclor[®] 1248 and 1260 concentrations in both samples from the onsite basin exceeded the screening criteria, though were substantially lower than concentrations

measured in OU2 streambed sediments. PCB Aroclor[®] 1260 concentrations measured in onsite basin samples were 490 $\mu\text{g/kg}$ at SD-08 and 260 $\mu\text{g/kg}$ at SD-09, while the Aroclor[®] 1248 concentrations were lower at 240 and 190 $\mu\text{g/kg}$. PCBs were not measured in the West Ditch samples.

4.5.4.2 OU2 Streambed Sediments

In OU2, the relationship between PCB Aroclor[®] 1248 and PCB Aroclor[®] 1260 concentrations was reversed from that in OU1, with PCB Aroclor[®] 1248 concentrations being much higher than PCB Aroclor[®] 1260 concentrations. PCB Aroclor[®] 1248 concentrations in surface sediment in Berry's Creek were 3,100 and 4,500 $\mu\text{g/kg}$ at stations SD-01 and SD-03, but below the IDL (33 $\mu\text{g/kg}$) at SD-02 and SD-04. The IDL is approximately equal to the screening criteria. PCB Aroclor[®] 1248 concentrations in the Diamond Shamrock/Henkel Ditch (north) ranged from 1,400 to 4,700 $\mu\text{g/kg}$.

PCB Aroclor[®] 1260 concentration was 320 $\mu\text{g/kg}$ at SD-03 and below the IDL at the other three stations. In the Diamond Shamrock/Henkel Ditch (north), PCB Aroclor[®] 1260 concentrations at SD-05 and SD-06 were also not detected with elevated IDLs (110 and 140 $\mu\text{g/kg}$). All of the IDLs are well above the screening criteria value.

4.6 Air Sampling

Air samples were collected during the Phase I field investigation, during the warehouse evaluation study, and by NJDEP. During the Phase I investigation, particulate mercury and total gaseous mercury were measured in five samples collected in September and October of 1997 and total gaseous mercury was measured in six samples collected in March 1998. In the supplemental warehouse study, gaseous mercury was measured at three locations inside the U.S. Life (Jerbil) warehouse and two outside locations in April 1999. Both particulate and gaseous mercury were measured by the NJDEP in 1989 and 1990. Particulate mercury is defined as particles 0.1 μm in size or larger. Complete chemical analysis results for air samples are presented in Appendix B1, Tables B1-11a and B1-11b. The daily meteorological conditions were obtained from nearby Teterboro Airport for dates that correspond with Phase I and warehouse evaluation air sampling periods (Appendix J).

In the September/October 1997 Phase I study, particulate mercury concentrations ranged from 0.10 to 1.66 ng/m^3 (Figure 4-33). The highest concentration was in the Wolf Warehouse. The lowest mercury particulate levels were in the U.S. Life Warehouse and at a location between the two warehouses. Gaseous mercury sampling was conducted concurrently with the particulate mercury sampling. Gaseous mercury concentrations ranged from 1.42 to 60.6 ng/m^3 (Figure 4-33). The highest concentration was within the undeveloped filled area, at sample location A-4, and the lowest was at the selected Site background location A-3.

In March 1998, also during Phase I, gaseous mercury measurements were made around the perimeter of the undeveloped filled area over the duration of the trenching activities. Gaseous mercury concentrations ranged from 2.85 to 14.43 ng/m³. The highest concentration was near the gate entrance to the undeveloped filled area at location B-3; the lowest was near the southern corner of the undeveloped filled area at location B-6. During the supplemental warehouse evaluation study conducted in April 1999, gaseous mercury concentrations from three locations inside the warehouse ranged from 8.8 to 16.6 ng/m³ and the two outdoor locations had concentrations of 8.79 and 13.1 ng/m³ (see Figure 2-3). Gaseous mercury levels were also monitored inside the warehouse using a Jerome mercury vapor meter and passive air traps. The monitoring results for readings made at breathing level height (approximately 1 meter) were below detectable levels (238 ng/m³ for the passive gold-coated sand traps and 0.003 mg/m³ for the Jerome meter). A few readings made with the Jerome meter directly over exposed soil beneath the concrete floor were equal to the detection limit and one reading at a depth of 2- to 4-ft at soil sample location WS-18 had a reading of 0.015 mg/m³.

The NJDEP (1991) conducted two rounds of air sampling in the vicinity of the Site. The first round was conducted on June 30, 1989, and the second round was conducted on October 29, 1990. Particulate and gaseous mercury samples were collected from six locations in the vicinity of the Site (three samples were within the Site boundaries) and one background location. Only one of these samples, a gaseous mercury sample located near the gate entrance to the undeveloped filled area, had a concentration (720 ng/m³) above detection limits. This concentration is an order of magnitude greater than gaseous mercury concentrations measured during the Phase I sampling in 1997. This difference may reflect the variability in mercury concentrations inherent in the sampling and analysis methods used, rather than the actual ambient air concentration. During the Phase I and warehouse evaluation studies, the iodated carbon sampling method and cold vapor atomic fluorescence spectrometry analysis method was selected because of greater sensitivity and precision than the National Institute for Occupational Safety and Health (NIOSH) method 6009 for gaseous mercury. The principal difference is the type of sorbent used; iodated carbon has a much lower blank value (approximately 0.5 ng/trap) than the hopcolite sorbent used in the NIOSH method (NIOSH 1997).

The time-weighted (10-hour) average exposure limit recommended by NIOSH (1997) is 50 µg/m³ for gaseous mercury. The highest concentration of gaseous mercury measured during the recent round of sampling (60.6 ng/m³) is approximately 1,000 times less than this exposure limit. The New Jersey indoor air criteria value for mercury is 300 ng/m³, which is six times greater than the highest value on Site (24 N.J.R. 386).

4.7 Hazardous Substance Inventory

As part of the hazardous substance inventory conducted in conjunction with the trenching activities, samples from six drums and four locations on the ground surface were collected. Sample locations were selected based on observations made during trenching activities and on a Site walk along the 100×100-ft control grid. A summary of chemical

analysis results is presented in Appendix B1, Table B1-12. In addition, nine discretionary soil samples were collected from the test pits. Although labeled as part of the subsurface soil sampling program (see Section 2.2.3), these samples were also collected from locations in the trenches with obvious discoloration or waste deposits, rather than from materials that could be reasonably classified as soils. A summary of chemical analysis results for the discretionary samples is presented in Appendix B1, Table B1-5.

All hazardous substance samples were analyzed for TAL metals, and the results were screened against the NRDCSCC. The samples collected from the three drums exhumed from the test pits did not have metals concentrations above the NRDCSCC values. Of the three surface drums sampled, the arsenic concentration at location HS-4 (29.1 mg/kg) and the mercury concentration at HS-7 (3,550 mg/kg) exceeded NRDCSCC values.

Three of the four surface samples collected during the Site walk-through had metals concentrations that exceeded the screening criteria, as follows:

- Lead in the sample from HS-6 (47,600 mg/kg),
- Thallium in the sample from HS-6 (5.8 mg/kg),
- Mercury in the sample from HS-5 (295,000 mg/kg), and
- Zinc in samples collected from HS-2 (8,520 mg/kg) and HS-5 (188,000 mg/kg).

Four metals exceeded the NRDCSCC values in the discretionary samples collected from the test pits. These included:

- Arsenic concentrations in samples collected from locations TP-5 (21.3 mg/kg) and TP-7 (23.4 mg/kg),
- Copper concentrations in the samples from location TP-7 (10,500 mg/kg) and TP-19 (8,720 mg/kg),
- Lead concentrations in samples collected from locations TP-7 (816 and 6,020 mg/kg), TP-13 (58,200 mg/kg), and TP-19 (672 mg/kg), and
- Zinc concentrations in samples collected from locations TP-7 (2,060 and 7,980 mg/kg) and TP-19 (9,040 mg/kg).

No VOCs or SVOCs exceeded the NRDCSCC in the samples collected from the three drums exhumed from the test pits. Samples collected from the three surface drums, the ground surface, and discretionary samples were not analyzed for VOCs or SVOCs.

4.8 Supplemental Warehouse Evaluation

This section discusses the results of the supplemental evaluation of soil samples from under the floor of the US Life (Jerbil) warehouse, taken in April 1999 during renovations to that warehouse. Figure 2-3 shows the sample locations and Table B1-3 in Appendix B1 presents the complete chemical analysis results. Mercury concentrations for the exterior samples, WS-17, 18, and 19 were included with the discussions of surface soils, for the 0- to 2-ft depth interval samples (Section 4.1.1 and Figure 4-1), and subsurface soils, for the 2- to 4-ft depth interval (Section 4.1.3 and Figure 4-9). This section discusses only the interior samples, WS-01 through WS-15. Note that no sample was collected at proposed location WS-16.

The highest mercury concentration in the interior samples was 3.44 mg/kg in WS-12. All other mercury concentrations were below 1 mg/kg. A composite sample from locations WS-1 through WS-15 was analyzed for the same analyte list used for the offsite soils. Of these analytes, only copper, lead, and zinc were detected, all at concentrations below the NRDCSCC and RDCSCC values.

Because of the encapsulated nature of the soils beneath the Wolf Warehouse, no data are available on mercury concentrations for these soils. As noted in the discussion of mercury in surface and subsurface soils, mercury concentrations in soil samples from locations adjacent to the Wolf Warehouse (e.g., SS-04, MW-13) contain elevated concentrations of mercury.

4.9 Chemical Data Quality Assessment

A quality assurance review of the chemical analysis results was performed by an independent reviewer retained by Exponent. Data validation procedures and qualifier assignments were completed according to EPA national functional guidelines for evaluating inorganic and organic analyses, as applicable (U.S. EPA 1994a,b). Data validation was completed to EPA Level III specifications (U.S. EPA 1995). The procedures and results of the quality assurance review, in addition to laboratory case narratives and nonconformance summaries, are presented in Appendix M. The results from the quality control samples collected in the field, including sample duplicates, equipment rinsate blanks, and trip blanks (for VOCs only), are presented in Appendix L.

This overall program review indicated that the data quality objectives identified in the QAPP (PTI 1997) for the Phase I and IA investigations were met.

In Phase I, however, some quality issues were noted by the data quality reviewer and are discussed in the quality assurance review summary presented in Appendix M. In summary, several TAL metals were detected in the initial and continuing calibration blanks above the applicable action limits, which resulted in approximately 13 percent of the samples being restated as undetected by the reviewer. Method and equipment rinsate

blanks at concentrations above applicable action limits for VOC and SVOC analyses resulted in less than 1 percent of samples being restated as undetected. Qualifiers assigned to undetected values during the review process are labeled as “*U*” in the data tables presented in Appendix B and can be distinguished from the laboratory qualifiers that are labeled as “*u*.” Problems with accuracy and precision, including calibration and internal standards, and recoveries of matrix spikes and surrogate compounds outside the control limits, resulted in approximately 10 percent of the samples being restated by the reviewer as estimated (*J* qualifier).

For Phase IA, the laboratory performing the chemical analyses, except mercury, was changed. The results reported by the Phase IA laboratories (Columbia Analytical Services and Cebam Analytical) are acceptable as reported and as qualified during the assessment of data quality. No results were rejected. During the assessment of data quality, 49 values were restated as estimated (*J* qualifier) due to low matrix spike recoveries, instrument calibration exceedances, low surrogate recoveries, or poor internal standard response. Sixty-one values were restated as undetected (*U* qualifier) because these values (primarily metals) were less than 5 times the concentration measured in the laboratory method blanks.

For the Phase IA SFI in 2002, a total of four results were qualified as estimated (*J*) and 17 results were restated as undetected (*U*) due to detection of analytes in the equipment rinsate blanks. No results were rejected.

In accordance with the Work Plan, NJDEP has validated a subset of the laboratory analytical results.

5.0 Transport and Fate of SoPCs

The purpose of this section is to characterize the transport and fate processes that produced the current distribution of SoPCs in the environment at the Ventron/Velsicol Site and that may alter their distribution in the future. These processes need to be characterized at a level sufficient to support risk management decisions such as those that will be associated with the feasibility study.

Transport and fate of substances in the environment refers to movement of substances in the environment and alterations of those substances during that movement. Transport processes can include movement of free-phase substances and movement of the environmental media (such as water, soil, sediment, or air) with which the substances are associated. These processes can also include transfers between different environmental media, such as the partitioning of substances between the dissolved and solid phases in water. Substance alterations in the environment occur through many different processes. Examples of particular importance for the Site are the transformations of mercury between different forms, especially between inorganic and organic forms, as in the methylation and demethylation of mercury and the formation of various inorganic mercurial species, such as mercuric sulfide. The fate of a substance refers to the location and state in the environment in which it eventually exists. For all transport and fate pathways, the behavior of a specific SoPC depends on the physical motion of the medium with which the SoPC is associated, the physical/chemical properties of that medium, and the physical/chemical properties of the SoPC itself.

Section 5.1 discusses potential fate and transport (migration) pathways and issues of relevance to SoPCs at the Site, principally the physical movement and physical/chemical properties of the environmental media as they influence SoPC transport and fate. Those pathways that are most relevant for this Site are discussed further in subsequent sections, based on the analysis in Section 5.1. The subsequent sections, 5.2 through 5.5, discuss the medium-specific behavior of mercury, the other metal SoPCs, the SVOC and PCB SoPCs, and the VOC SoPCs for the selected pathways.

Section 5 discusses fate and transport processes that apply to OU1, including transport to OU2. All referenced criteria values can be found in Tables 4-1 through 4-7 and in Appendix B.

5.1 Potential Migration Pathways

This section discusses the significance of potential migration pathways in relation to the identified sources. The two distinct areas of OU1 (developed area and undeveloped filled area) were each treated as potential source areas for migration, either away from the Site or between areas of the Site. SoPC concentration differences within each area, and the

potential for migration within each area, are of less significance than the potential for migration away from each area. Migration within each of the two areas, therefore, was evaluated only to the extent that it influences potential migration away from the area.

Potential active contributions to OU1 from offsite sources were not evaluated, because SoPCs identified at the Site are expected to be residuals from past activities. Introduction of new SoPCs to the Site from the WRCC facility had ended by 1974, as had placement of fill into the undeveloped filled area. With the remediation of the Diamond Shamrock/Henkel property, releases from that property, except for migration in environmental media, would also have ended. Of the neighboring industrial facilities, only Randolph Products is still active, and potentially an active source of releases to the Site.

Potential transport media for SoPCs in the developed and undeveloped filled areas, therefore, include soils, groundwater, seeps, surface water and sediment (from the onsite basin and the West Ditch), and air. Potential migration pathways for SoPCs from soil include migration of eroded soil particles in surface water, leaching from soil into surface water or groundwater, volatilization of SoPCs from soil to air, and suspension of soil/dust particles in air. Groundwater, seeps, and surface water serve as migration pathways by transporting SoPCs in either dissolved or particulate form. The two former drainage pipes or drainage features that may have been installed between the developed portion of the Site and Berry's Creek (see Section 1.3) could constitute a preferential pathway for offsite migration of contaminants.

The potential migration pathways from sediment are by dissolution into surface water or suspension of particulates into the water column and subsequent transport with the water. Over time, sediment may be suspended into the water column and deposited again as sediment at various locations. Air is also a migration pathway because the potential exists for volatile SoPCs and dust particles (fugitive dust) to be transported away from the Site as air moves. The rationale for selecting the pathways under consideration in Sections 5.2 through 5.5 is discussed below.

5.1.1 Soil, Groundwater, and Seeps

Soil—Soil may participate in SoPC migration pathways either directly, through soil erosion by water or air, or indirectly, through transfers of SoPCs to other media that subsequently migrate (e.g., volatilization of SoPCs from soil to air or leaching of SoPCs into groundwater or surface water). The indirect ways that soil participates in SoPCs migration are discussed under the respective media (i.e., air, groundwater, and surface water). Surface soil erosion by water or air from OU1 is expected to be limited because of the existing surface cover. Except for the narrow Ditch along the southwest side of the railroad tracks behind the Wolf warehouse, the developed area is entirely paved, occupied with buildings, or covered with trap rock (for the railroad bed), and the undeveloped filled area is heavily vegetated. No areas of soil erosion were noted during the field studies. None of the four air sampling data sets discussed in Section 4.6 indicate that air

is a significant transport pathway for either gaseous or particulate mercury. The data from the mercury samples can be used to infer that transport by airborne particulates is not likely to be significant for any of the other SoPCs.

It is possible, however, for surface soil (or other particulate matter on the surface of the pavement in the developed area) to be eroded by water from the developed and undeveloped fill areas during precipitation and/or flooding events. Eroded particulate matter in surface runoff from the developed area is likely to either end up in the drainage swale between the two warehouses or run directly onto the undeveloped filled area. Prior to the installation in 1961 of the railroad tracks that border Ethel Boulevard on the north side of the Site, surface soil from the former mercury processing facility could have been eroded by water from surface runoff or by wind and transported north of the Site to the area that is now between the railroad tracks and the Blum and Berger warehouses. It is also possible that contaminated soil in this area originated from historical operations of the facility, which extended north of the current railroad tracks. The combination of curbs and the slope of the pavement currently prevents surface water transport off the Site in directions toward Ethel Boulevard or Park Place East. Plate 1 shows the current site topography.

The potential for offsite transport from the drainage ditch between the warehouses is uncertain. According to a Site plan drawing prepared by Rutenberg/Kolarando AIA, dated July 15, 1974, water that accumulated in the ditch was to drain through culverts under the railroad spur, into a ditch behind the railroad tracks along the Wolf (Blonde) warehouse, and then toward Berry's Creek in a 24-in.-diameter concrete pipe. Observations during the supplemental Phase IA investigation suggest that this drainage pathway is not currently operating, perhaps due to siltation or collection of other debris somewhere along the drainage system. Under current conditions, if sufficient water accumulates in the ditch between the warehouses, the excess water most likely drains from the Site through the West Ditch. Surface runoff from the undeveloped area may enter Berry's Creek and the marsh area.

Prior to remediation of the Diamond Shamrock/Henkel facility, contaminants could have migrated from the Diamond Shamrock/Henkel property to OU1 and the West Ditch via soil erosion. Currently, no contaminant transport via soils from the Diamond Shamrock/Henkel property to OU1 is apparent.

Groundwater—The key groundwater issue at this Site is the potential for migration of SoPCs in groundwater from the Site to the adjacent surface water bodies at concentrations high enough to be of potential significance with respect to surface water quality. This issue was addressed in the SoPC screening process by comparing the concentrations measured in the “perimeter” wells (i.e., those closest to surface water bodies along all flow paths from the Site) to the SWQS. The potential for leaching to and migration in groundwater with respect to Site groundwater quality is also evaluated in this section because the current groundwater classification of II-A (see Section 3.6) at the Site includes potable water supply as an allowable use. Further, the bedrock aquifer may be used as a water source in the region of the Site.

At this Site, the groundwater surface (piezometric surface) is generally shallow (less than 10 ft bgs), and near-surface groundwater is expected to discharge principally to Berry's Creek and the Diamond Shamrock/Henkel Ditch (north). Some Site groundwater also may discharge directly to the marsh area south of the undeveloped filled portion of the Site or to the West Ditch. The developed area is almost completely paved or occupied by buildings, limiting the opportunity for infiltration of surface runoff to groundwater. In the undeveloped filled area, the potential for infiltration (and thus the potential leaching of contaminants to groundwater) is greater than in the surrounding areas. The greater rate of infiltration creates the groundwater mounding and associated radial flow pattern observed in this area (Figures 3-4a, b, c, and d). This pattern of groundwater flow typically includes a downward flow component near the center of the groundwater mound, which then turns upward as the flow approaches the discharge areas.

As discussed in Section 3, the marsh area is expected to be an area of local and regional groundwater discharge. The entire Site was likely an area of groundwater discharge before it was filled. As portions of the Site became filled, they became local recharge areas. In the marsh, tidal cycles are expected to have a short-term influence on the discharge rate into the marsh, with discharge slowed during high tide and accelerated during low tide. The longer-term regional hydraulics and the mean water level in the marsh, however, govern the average discharge rate into the marsh.

The field measurements shown in Tables 5-1a, b, and c show that groundwater on the Site has generally low dissolved oxygen content (i.e., anoxic) and negative oxidation-reduction potential values. In Phase I, the highest concentrations of dissolved oxygen were 1.25 mg/L at MW-6 and 1.13 mg/L at MW-9. All other values were at or below 0.5 mg/L. Due to potential introduction of air into field instruments, even the values around 1 mg/L may indicate the essential absence of oxygen. The Phase I oxidation-reduction potential values were all negative, except for the most upgradient well (MW-10). This indicates that the reducing conditions most likely are created as the groundwater moves under the Site. In Phase IA, several wells had higher dissolved oxygen concentrations. Wells MW-6, 7, 8, 9, 12, 13, and 15 had dissolved oxygen concentrations ranging from 1.5 to 5.23. Also, the oxidation-reduction potential values at four wells, MW-2, 9, 10, and 14 were greater than zero in Phase IA. These values indicate that stronger reducing conditions existed during the Phase I sampling than during the Phase IA sampling. The Phase IA values, however, still indicate generally reducing conditions over much of OU1, especially in the undeveloped filled area.

In the developed area, the pavement would be expected to reduce infiltration of air, compared to an unpaved surface, potentially contributing to the chemically reduced conditions in the groundwater beneath this area. In the undeveloped filled area, decomposition of the organic material in the fill may contribute to the anoxic reducing groundwater conditions. The underlying organic-rich marsh soils (commonly known as meadow mat) at the Site may also contribute to the reducing conditions through oxygen depletion by decaying organic matter.

Sulfide concentrations in groundwater measured in Phase IA ranged from below the IDL (1 mg/L) to 8.2 mg/L, though the second highest concentration was only 1.5 mg/L. The wells at which sulfide was below the IDL were MW-1, 3, 4, 9, 11, and 15. A dynamic balance of sulfide production by sulfate reducing bacteria and sulfide precipitation as it forms insoluble complexes with various metals typically governs sulfide concentrations in groundwater. The production rate can also be limited by the availability of sulfate and organic carbon, though both of those are generally plentiful in OU1. The presence of any detectable sulfide in groundwater, however, is a strong indication of anoxic and reducing conditions. Further analysis would be needed to fully evaluate the factors that influence sulfide concentrations at this Site.

The influence of factors other than sulfate concentration can be seen by comparing some of the sulfate and sulfide values. In Phase IA, MW-12 had the highest sulfide concentration and had the second highest sulfate concentration. However, in MW-3 sulfides were below the IDL and it had the highest sulfate concentration. The sulfide concentrations were generally an order of magnitude or more below the sulfate concentrations. However, as illustrated by MW-3 and MW-12, there does not appear to be a strong correlation between the sulfide and sulfate concentrations. Also, sulfate was not detected in the Phase IA sample from MW-5, but that sample had the second highest sulfide concentration. MW-3 and MW-12 had the highest sulfate concentrations in both Phases I and IA. These higher sulfate concentrations may be related to the sludge material deposited on the Site that consisted mainly of calcium sulfate (Bratt 1962).

Geochemical conditions represented by low oxygen content and negative oxidation-reduction potentials can have a strong impact on the behavior of metals in groundwater. For example, under these reducing conditions, iron and manganese tend to transform into soluble forms, enhancing their mobility in groundwater. However, some metals can form insoluble complexes with sulfides under these conditions. Several metals SoPCs at this Site (notably cadmium, copper, lead, mercury, nickel, silver, zinc, and to a lesser extent, arsenic) behave in this way, thereby potentially reducing their mobility in groundwater (Innovations in Ground Water and Soil Cleanup 1997).

Where present, the meadow mat is expected to serve as an obstacle to potential downward migration of dissolved VOCs, SVOCs, and mercury because these substances will sorb to the organic material in this soil layer. This sorption, and subsequent retardation of the dissolved substance, will continue as long as there are receptor sites on the organic materials in this meadow mat layer. After the receptor sites are filled, the dissolved substances will move with the water without being retarded.

While the groundwater in the undeveloped filled area has strongly reducing conditions typical of landfill environments, many of the groundwater conventional parameters are not typical of municipal landfill leachate. Table 5-2 summarizes groundwater quality data for landfills (U.S. EPA 1988b). Comparing the values of dissolved metals and conventional parameters in Tables 4-4a through d and 5-1a through c to those in Table 5-2, it can be seen that except for mercury and sulfate, the OU1 groundwater concentrations are generally much lower than those reported as typical of landfills. The

mercury and sulfate concentrations in OU1 groundwater have a similar range to that reported in Table 5-2. The relatively low biochemical oxygen demand concentration compared to values typical of municipal landfill leachate may indicate that the materials deposited on Site have relatively low putrescible organic matter content, compared to typical municipal landfills. These data are consistent with both the observation of materials in the test pits (see Section 3.4.2 and Appendix D) and the restriction on dumping household garbage in the agreement that allowed the Borough of Wood-Ridge to dump on the Site (Attachment A to the BITM, Volume 4). The cited references did not provide metals concentrations from solid material samples, so it cannot be determined if the difference in groundwater metals concentrations is due to lower metals content in the landfilled material or to different geochemical conditions. Sampling and analytical method differences may also account for some of the variance.

Seeps—Dissolved SoPC concentrations in seeps provide a qualitative indication of the potential for net migration of SoPCs from OU1 to the adjacent surface water bodies. When dissolved SoPC concentrations in seep samples are higher than surface water concentrations (excluding samples taken at low tide), the concentration difference may reflect net migration from the Site to the adjacent surface water bodies.

Seeps are likely to consist of a blend of surface water exfiltrating from the bank and groundwater discharging from the Site. As the water level in Berry's Creek and the Diamond Shamrock/Henkel Ditch (north) rises during a tidal cycle, water infiltrates into the Creek and ditch banks. When the creek and ditch water level falls, water exfiltrates from the banks. Over time, the amount of water that infiltrates should be almost equal to the amount that exfiltrates. Additionally, groundwater is discharging to Berry's Creek and the Diamond Shamrock/Henkel Ditch (north), creating a net outflow of water from the undeveloped filled area to the adjacent surface water bodies.

In the portion of the seep water that is exfiltrating surface water, the dissolved SoPC concentrations reflect both concentrations in the surface water that infiltrated the bank and changes to those concentrations (either increases or decreases) caused by contact with the Site soils. Some suspended solids may also be carried with the infiltrating water. All but the smallest suspended solids, however, are likely to be filtered out rapidly as the water infiltrates the soils of the creek bank. For the portion of the seep that is discharging groundwater, the SoPC concentrations reflect net migration from the Site. As discussed in Section 4.3, only the dissolved concentrations, from the filtered seep samples, were used to evaluate the transport of SoPCs. The unfiltered seep samples contain particulate matter that may have come from surface sediments introduced during sampling.

We have not at this time attempted to estimate net migration rates in groundwater from the Site to the surrounding surface water bodies. Such an analysis would involve a high degree of uncertainty. In addition to the uncertainties associated with estimating net migration rates from the Site, the significance of any net migration from the Site could not be determined by considering only contributions from this Site, because there are many potential sources of SoPCs to Berry's Creek. The screening process used to select SoPCs, however, did identify those substances that have the potential to migrate from the

undeveloped filled area to the adjacent surface water bodies at concentrations of significance with respect to surface water quality.

5.1.2 Surface Water and Sediment

Surface water can act as a potential migration pathway by carrying dissolved or particulate SoPCs either to other surface water bodies or to groundwater. Surface water in OU1 will drain either toward OU2 or the West Ditch, except for a small area in the northern part of the undeveloped filled area that may drain initially toward the developed area before heading southeast along the Wolf warehouse toward the West Ditch. The only surface water bodies in OU1 are the onsite basin and the West Ditch. The ditch between the warehouses also frequently contains standing water.

The onsite basin does not have any apparent direct discharge to adjacent surface water bodies such as the Diamond Shamrock/Henkel Ditches. However, the July 15, 1974, Rutenberg/Kolarando Site plan suggests that the onsite basin may at some time in the past been on the pathway, perhaps as a settling basin, for drainage from the developed area. In its current condition, the only pathway for offsite migration of SoPCs from the onsite basin would be through overflow during heavy rainfall events. We have not estimated the amount of rainfall needed to cause the onsite basin to overflow. As can be seen by comparing Figures 2-1d and 3-2, the onsite basin is above the 500-year floodplain.

The West Ditch discharges to the Diamond Shamrock/Henkel Ditch (north) and may, therefore, be a direct pathway for SoPCs that are in the West Ditch to migrate away from OU1.

In the developed area, the pavement and buildings have been limiting contact between rain and SoPCs in the soil since the mid-1970s, so transport of SoPCs in surface runoff is not expected to be a significant issue. In the undeveloped filled area, SoPCs may be transported in either dissolved or particulate form to Berry's Creek or the Diamond Shamrock/Henkel Ditch (north) and marsh area by surface runoff during precipitation and/or flooding events. As shown in Figure 3-2, however, most of the undeveloped filled area is above the 500-year floodplain.

Surface water in the onsite basin and West Ditch may be hydraulically linked to groundwater at the Site. The onsite basin has contained water during all field investigation activities and appears to contain water in all historical aerial photographs that show the basin. After storm events, when the basin receives surface runoff it may recharge the groundwater, and between storm events, groundwater may recharge the basin. Water in the onsite basin most likely includes both surface runoff and groundwater.

Sediments in OU1 are limited to the onsite basin, the West Ditch, and the drainage ditch between the warehouses. Prior SoPC releases may be bound in the sediments and have the potential to influence surface water and groundwater quality through sediment/water

interactions. The onsite basin and ditch between the warehouses are likely to be areas of sediment accumulation. However, West Ditch sediments could be gradually transported to OU2 by flowing water, especially during periods of flooding. The drainage pathway for the ditch between the warehouses is apparently blocked. If that blockage were to be removed, accumulated sediment could potentially be transported to OU2. As described above for developed area soils, the buildings and pavement have been in place since the mid-1970s. Any sediment accumulated in the warehouse ditch is post-development, and therefore would not be expected to contain any Site related SoPCs. Migration of Site SoPCs from the sediment is not likely to be a significant issue.

5.1.3 Air

SoPCs can enter the air through volatilization (in the case of volatile substances such as elemental mercury) or through suspension of dust particles that contain SoPCs. As mentioned in Section 5.1.1, the Site is not expected to generate appreciable amounts of fugitive dust because of the surface cover—pavement in the developed area, thick vegetation in the undeveloped filled area, and a combination of thick vegetation and water in the marsh. Volatilization is a potential pathway of migration for SoPCs. Other than mercury, the only SoPCs with appreciable potential for migration via volatilization are VOCs. The VOC SoPCs were found in only a few areas of the Site and were not found above screening criteria values in soils. Only mercury volatilization, therefore, was evaluated further.

5.1.4 Summary of Potential Sources and Migration Pathways

Based on the evaluation described above, the following potential sources and associated potential migration pathways were selected for further evaluation in Sections 5.2 through 5.5.

- Developed area
 - Soil contamination potentially leaching into groundwater
 - Soil contamination leaching to groundwater that migrates along the suspected former drainage pipes or features to Berry's Creek
 - Groundwater contamination that migrates along the suspected former drainage pipes or features to Berry's Creek
 - Soil contamination potentially volatilizing into the air (mercury only).

- Undeveloped filled area
 - Soil contamination potentially leaching into groundwater
 - Soil contamination leaching to groundwater that migrates along the suspected former drainage pipes or features to Berry's Creek
 - Groundwater contamination that migrates along the suspected former drainage pipes or features to Berry's Creek
 - Soil contamination potentially dissolving in surface water runoff and being transported to OU2 surface water
 - Soil contamination potentially migrating with eroded soil particles to OU2 surface water and sediment
 - Soil contamination potentially volatilizing into the air (mercury only)
 - Soil contamination potentially being transported into the air through wind erosion (mercury only)
 - Groundwater contamination discharging to OU2 surface water
 - Bank seeps discharging to OU2 surface water
 - West Ditch surface water discharging to OU2 surface water
 - West Ditch sediment contamination being transported to OU2 surface water and sediment.

Except for the potential migration of SoPCs from surface soil to surface water and along the suspected former drainage pipes or features, these potential sources and pathways are discussed in the following sections for the SoPCs listed for each medium in the Section 4 tables. For the potential migration of SoPCs from surface soil to surface water and along the suspected former drainage pipes or features, we recognize the theoretical possibility that such migration could occur for any of the SoPCs listed in Tables 4-1a through c. However, none of the data available to this remedial investigation effort are adequate to quantify the potential impact of such migration. This issue will be addressed further at a later time if needed for purposes of decision-making or remedy design in subsequent phases of the remedial planning process.

5.2 Mercury

This section contains a discussion of the general behavior of mercury in the environment (Section 5.2.1), followed by a discussion of the Site data (Sections 5.2.2 through 5.2.4).

5.2.1 Behavior of Mercury in the Environment

The transport and fate of mercury in the environment varies with the physical and chemical properties of the various mercurial species. The majority of mercury in the environment occurs as inorganic mercury—either elemental mercury (Hg^0) or mercuric ion (Hg^{2+}). Mercuric ion forms a variety of complexes with anions (e.g., Cl^- , OH^- , and S^{2-}) and adsorbs to mineral colloids (Schuster 1991). Mercuric ion has a particularly strong affinity for sulfide (conditional stability constant of $[\text{Hg}^{2+}][\text{S}^{2-}] = 10^{53.9}$; Dyrssen 1989), including sulfide occurring as sulfhydryl bonds present in organic matter. Organic mercury compounds (e.g., methylmercury, not mercury associated with organic matter) are typically a small fraction (less than one percent) of mercury in the environment, even in soils that are contaminated by industrial production of organic mercury compounds (Hintelmann et al. 1995). Under certain environmental conditions, which are not known to be present at this Site (such as an anoxic hypolimnion of a lake), methylmercury concentrations can be a much higher percentage of mercury concentrations (Jacobs et al. 1995). The following text discusses migration potential and transformation of mercury in soil, water, sediment, aquatic biota, and air.

Migration in Soil and Water Systems—Mercury in soil tends to be relatively immobile because of the tendency of mercury to associate with soil particles, soil organic matter, and sulfides (Schuster 1991). The principal soluble complexes of mercuric ion are $\text{Hg}(\text{OH})_2$, HgCl_2 , and Hg-S-R , where R represents organic ligands containing sulfhydryl groups (Schuster 1991). The relative concentration of each complex depends on pH, oxidation-reduction potential, and ligand concentration. The principal ligand for soluble complexes of methylmercury is dissolved organic matter.

Mercury entering surface water is subject to partitioning between dissolved and particulate phases. Most mercury in water associates with particles such as organic particulate matter and mineral colloids. Gill and Bruland (1990) found that up to 92 percent of total mercury was associated with the particulate fraction in surface water samples from California and other areas. Mercury concentrations in filtered water samples, hence, tend to be considerably lower than in unfiltered samples. This pattern holds true for this Site, as can be seen in Tables 4-5a and b and 4-6a through c.

Because mercury associates readily with particles, the fate of inorganic mercury in surface water is principally a function of the fate of particles. Over time, particles settle to the bottom of the water column and become part of the sediment. In quiescent waters, such as the onsite basin, sediment remains in place and the ultimate fate of mercury associated with particles in these systems is burial. In moving waters, such as creeks and marshes, surface sediments may be resuspended and transported with the water, and subsequently redeposited at a downstream location.

Transformations in Soil and Water Systems—Methylmercury, the organic mercury species of greatest concern because of its potential toxicity and tendency to bioaccumulate, can be formed both biologically and chemically in the environment. This process is called methylation. Methylmercury can also be degraded to elemental

mercury. This process is called demethylation. The occurrence of methylmercury at the Site is discussed in terms of both concentration and as a percentage of mercury. In general, methylmercury concentrations are a function primarily of conditions that affect methylmercury formation. Mercury concentrations may also have some influence on methylmercury concentrations. Conditions that favor methylmercury formation are discussed below and include low oxygen concentration, moisture, microbial activity, and the presence of methyl-group (CH_3^-) donors, such as humic matter. Conditions that favor demethylation are also discussed.

Soil—Chemical and biological transformations of mercury in soil include mercury reduction and mercury methylation. Mercuric ion reduction to elemental mercury (a volatile mercury species) results in mercury volatilization to the atmosphere (and consequent loss from soil). Biological methylmercury formation rates in soils are highest under anoxic conditions that favor sulfate-reducing bacteria, the primary methylators of mercury in the environment (Compeau and Bartha 1985). The presence of sulfide (which is produced by sulfate reduction), however, can inhibit methylmercury production through the formation of stable mercuric sulfide complexes. Little is known about rates of chemical (i.e., abiotic) methylation of mercury, but it is suspected to occur by the reaction of methyl-group donors, such as humic acid, with mercuric ions in aquatic systems (Weber 1993). Methylmercury concentrations are usually low in surface soil, because methylation rates in dry, oxic soil are generally negligible.

Water—Transformations of mercury in water include reduction, methylation, and demethylation. Mercuric ion reduction to elemental mercury, followed by volatilization, is considered to be a light-induced reaction in surface water that accounts for loss of mercury to the atmosphere. Methylation rates are generally lower in water than in sediment. As in soil, methylmercury concentrations in oxic surface water are generally a small fraction of mercury. Demethylation is an active process in surface water and is thought to result from photodegradation (Sellers et al. 1996). Demethylation effectively removes methylmercury from the system by transforming it into elemental mercury, which volatilizes to the atmosphere. Methylmercury, therefore, can be considered short-lived in surface water where oxygen and light are present.

Transport in Aquatic Biota—Another form of mercury transport in surface water and sediment is uptake into aquatic biota. Mercury dissolved in water can enter aquatic biota by direct ingestion or by partitioning to phytoplankton, which form the base of planktonic (i.e., water-based) food webs. Direct ingestion of water is typically a minor route of exposure. Preferential partitioning to phytoplankton results in bioconcentration of methylmercury in phytoplankton, which can then be consumed by zooplankton, which in turn are consumed by fishes. Mercury associated with sediment can also be ingested by sediment-dwelling organisms such as benthic macroinvertebrates and bottom-feeding fishes. In benthic-based food webs, the concentration of mercury in sediment has a strong effect on the concentration of mercury in the food web. Mercury associated with organisms is transported with the organisms, may be released back into the environment through elimination, and is eventually released back into the environment when the organisms die.

Sediment—In sediment, mercury can continue to undergo transformations, principally methylation and demethylation. In anoxic sediment where sulfide is present, mercury occurs predominately in the form of mercuric sulfide, a very stable and insoluble form that has limited availability for other transformations. However, mercury methylation can proceed, to some extent, even in the presence of sulfide. The highest rates of methylmercury formation occur in anoxic sediment that contains sufficient sulfate to support sulfate-reducing bacteria, but not so much that mercury is sequestered as mercuric sulfide (Compeau and Bartha 1985; Gilmour and Henry 1991). Demethylation is also an active process in sediment and, in some cases, appears to be mediated by the same organisms that methylate mercury (Marvin-DePasquale and Oremland 1998). Abiotic demethylation is suspected to occur in the presence of sulfide, resulting in the formation of mercuric sulfide, which precipitates, and dimethylmercury, which volatilizes to the atmosphere (Craig and Bartlett 1978).

Air—Unlike most metals, mercury can volatilize from soil or water to the atmosphere in the form of elemental mercury (Hg^0). Elemental mercury is formed by the chemical or biological reduction of mercuric ion (Hg^{2+}). Mercury reduction followed by volatilization from soil occurs primarily near the soil surface and is mediated by sunlight (Carpi and Lindberg 1997). Increases in soil temperature result in higher measurements of mercury vapor flux across the soil surface (Gustin et al. 1997; Lindberg et al. 1995). The concentration of mercury in the air above soil is a function of flux from the soil, background concentrations in air, and weather conditions. Mercury concentrations in air can increase if soil is enclosed (e.g., covered by a shed) or if there is a stagnant mass of air over the Site. Mercury vapor is heavier than air and, under quiescent conditions, can settle into low areas. Moderate air movement, however, will cause mercury vapor to mix with the air column. Under most meteorological conditions, air overlying mercury-containing soil mixes readily with air from surrounding locations, resulting in rapid dilution of mercury concentrations. Mercury that volatilizes from the ground into the air, therefore, is expected to dilute rapidly.

5.2.2 Soil, Groundwater, and Seeps

Leaching from Soil to Groundwater—The Phase I, Phase IA, and Phase IA SFI groundwater data indicate that leaching of mercury from soil to groundwater is not producing groundwater concentrations above the GWQS except in the developed area (MW-13 and MW-15) and immediately adjacent to the developed area (MW-7) (Figure 4-13).

Migration of mercury in groundwater from the vicinity of these wells is limited to dissolved mercury. The supplemental Phase IA sampling of groundwater in 2000 at MW-7, MW-13, and MW-15 included analysis of both filtered (i.e., dissolved) and unfiltered samples for mercury. Unfiltered concentrations were lower than during previous sampling in 1999. Filtered mercury concentrations were 2.68, 8.47, and 0.924 $\mu\text{g/L}$,

respectively. These concentrations were 36, 57, and 32 percent of the unfiltered mercury concentrations, respectively.

Based on the immediate proximity to relatively high mercury concentrations in soil (Figure 4-1) and the ground water flow directions (Figures 3-4a, b, c, and d), the elevated mercury concentrations in samples from MW-13 and MW-15 are most likely related to mercury in soil in the developed area. Groundwater elevations in Figures 3-4a, b, c, and d show that the direction of groundwater flow is through the northeast corner of the undeveloped area in OU1 toward Berry's Creek for MW-13 and toward the West Ditch for MW-15. For MW-7, however, Figures 3-4a, b, c, and d show that the direction of groundwater flow in the vicinity of MW-7 is most likely going toward, rather than coming from, the developed area. The concentration of mercury in groundwater at MW-7, therefore, is not likely to be related to leaching from the soil under the developed area. Mercury in groundwater at MW-7 may be related to the relatively high mercury concentrations in surface soil in the vicinity of sample locations SS-10 and -18, located southeast of the developed area, or from groundwater flow through the onsite basin area (Figures 2-2 and 4-1). These soil sample locations and the onsite basin are generally upgradient of MW-7.

Methylmercury in groundwater is of little inherent concern because there is no direct pathway from groundwater to biota in which the methylmercury could accumulate. In recognition of this, there is no groundwater screening criterion for methylmercury. Nevertheless, methylmercury in groundwater provides some indication of the potential for methylmercury formation in OU1. Methylmercury as a percentage of total mercury ranged from 0.001 to 0.4 in the developed area and from 1 to 14 in the undeveloped area (except at MW-5 in Phase I where the percentage was 0.9). These data suggest that subsurface conditions for methylmercury formation are more favorable in the undeveloped area than in the developed area. Potential methylmercury migration from groundwater to surface water is discussed in the next section.

Migration to Surface Water from Groundwater and Subsurface Soil—Mercury concentrations in groundwater wells adjacent to surface water bodies and in seeps can be used to assess the potential for migration to surface water from groundwater and from dissolution of SoPCs into water that infiltrates the bank during high tide. Seven wells in Phase I (MW-1, MW-3, MW-4, MW-5, MW-6, MW-8, and MW-12) and eight wells in Phase IA (the Phase I list plus MW-15) were used to assess potential migration to surface water in groundwater. These wells will be collectively called the downgradient perimeter wells. It should be noted that this terminology is not quite accurate, since due to the radial flow in the undeveloped area MW-14 is also downgradient from, and on the perimeter of the Site, but the term will be used for convenience. Seep concentrations, as discussed earlier, represent a combination of groundwater and surface water that has previously infiltrated into the creek bank. Only filtered sample concentrations are used when discussing the seep sample results due to the difficulty of collecting a sample without entraining sediment from the creek bank.

Mercury concentrations in the downgradient perimeter wells and seeps exceeded the SWQS in Phase I samples at wells MW-5 and MW-8 and seeps SE-04 and SE-06, while Phase IA sample concentrations exceeded the SWQS at MW-3, MW-5, MW-8, MW-12, and MW-15 (Figures 2-2 and 4-13). It should be noted that the Phase I IDL for mercury was higher than the SWQS.

The two seeps in which mercury concentrations exceeded the SWQS in Phase I, SE-04 and SE-06, are both located along Berry's Creek north of the tide gate, close to MW-5. The dissolved mercury concentration in SE-06 ($1.8 \mu\text{g/L}$), which is closest to MW-5, was higher than in MW-5 ($0.57 \mu\text{g/L}$), while the concentration in SE-04 ($0.32 \mu\text{g/L}$), which is upstream from SE-06, was lower than in MW-5. Dissolved mercury concentrations in SE-04 and SE-06 were also higher than any of the dissolved total mercury concentrations in surface water samples from Berry's Creek. MW-5, SE-04, and SE-06 are in the vicinity of the suspected location of the former WRCC facility discharge to Berry's Creek. At all other locations, the mercury concentrations in seeps are an order of magnitude or more lower than mercury concentrations in nearby wells. This difference in concentrations suggests that mercury concentrations in groundwater may be attenuated significantly in the zone between the monitoring wells and the creek bank.

Dissolved methylmercury was detected in all downgradient perimeter wells and all seeps in both Phases I and IA (Figure 4-14). Dissolved methylmercury concentrations in the seeps along the Diamond Shamrock/Henkel Ditch (north) were similar in magnitude to dissolved methylmercury concentrations in surface water, and about an order of magnitude lower than methylmercury concentrations in groundwater, again suggesting attenuation in the zone between the monitoring wells and the creek banks. For the seeps into Berry's Creek, methylmercury concentrations at SE-03 and 03A, SE-04 (both Phases I and IA), and SE-06A were similar to concentrations in groundwater, while at SE-06, the dissolved methylmercury concentration ($0.0003 \mu\text{g/L}$) was an order of magnitude lower, comparable to the surface water concentrations. These data suggest that there is either less attenuation of methylmercury as the groundwater flows through the soil in this region or greater dissolution of methylmercury into surface water that infiltrates the creek banks than along the Diamond Shamrock/Henkel Ditch (north).

Offsite Soils—Mercury was delineated horizontally and vertically to below the RDCSCC value in offsite soils, with one exception (borehole B-13). Sample locations adjacent to the northern boundary of the Site (i.e., on the north side of the railroad tracks that border Ethel Boulevard) had values higher than the RDCSCC, including some exceedances at depth in the area closest to the former mercury processing facility (i.e., borehole B-13). Mercury in offsite surface soils located further from the Site boundary were below the RDCSCC. Only one offsite sample (SS-67, located at the western corner of the Blum warehouse) contained mercury in excess of the NRDCSCC. The source of mercury to these offsite soils adjacent to the northern boundary of the Site was likely historical plant operations in this area. The railroad tracks, a natural boundary for any migration, were not installed until 1961 when the mercury processing facility had been in operation for over 30 years. The presence of mercury above the RDCSCC in deeper intervals likely

resulted from regrading prior to construction of the Berger warehouse or vertical migration from surface soils.

Summary—The groundwater data indicates that leaching from soil to groundwater is not causing the groundwater screening criterion to be exceeded except at and immediately adjacent to the developed area. With regard to potential impacts on surface water, the groundwater and seep data together indicates that migration to surface water at concentrations above the SWQS is not likely, except perhaps in the area north of the tide gate along Berry's Creek.

Methylmercury concentrations in groundwater are generally an order of magnitude higher than in surface water. Methylmercury concentrations in the seeps varied, with values along the Diamond Shamrock/Henkel Ditch (north) generally similar to surface water and concentrations in seeps along Berry's Creek mixed, with some similar to groundwater values and some similar to surface water values. These data indicate the potential for net migration of methylmercury from the Site to Berry's Creek. Once in surface water, however, the methylmercury is expected to undergo demethylation to elemental mercury, which will volatilize.

5.2.3 Surface Water and Sediment

OU1—Water and sediment samples were taken from two distinct water bodies in OU1: the onsite basin and the West Ditch.

Surface water and sediment in the onsite basin are not likely to migrate from the onsite basin. The only feasible circumstance under which such migration might occur is a major flood that caused the onsite basin to fill and overtop the banks of the basin. The water and suspended sediment would then flow overland, probably to the West Ditch. If such an event were to happen, the concentration of suspended sediment would likely be low since water would not be flowing through the basin, rather, it would just be filling and overflowing.

Mercury concentrations in the two unfiltered samples from the onsite basin were 5.8 and 17.6 $\mu\text{g/L}$, while the concentration in the filtered samples were below the IDL of 0.2 $\mu\text{g/L}$, indicating that essentially all of the mercury is associated with particulate matter in the water. Methylmercury as a percentage of total mercury for the unfiltered samples was in the same range as was found in the OU2 surface water samples.

Mercury concentrations in the onsite basin from the two sediment sample locations at both depth horizons (0- to 2-cm and 0- to 15-cm) fell within a fairly tight range. Three of the four values ranged between 1,180 and 1,280 mg/kg, and the fourth was 856 mg/kg. Mercury concentration in the 0- to 2-cm horizon was nearly identical to that in the 0- to 15-cm horizon at SD-08, and about a third lower than the 0- to 15-cm horizon at SD-09. In the relatively quiescent waters of the onsite basin, the sediment near the surface is expected to be more recently deposited than deeper sediment. The data, therefore, may indicate that more recently deposited sediments at the southeastern end of the basin have

lower mercury concentrations than older sediments, or may simply reflect heterogeneity in the sediment. The general uniformity of these measured mercury concentrations, both laterally and vertically, may indicate that mercury in the onsite basin sediment may be related to conditions that affected the entire basin uniformly and remain stable for an extended time period. The data do not, however, necessarily indicate that there is a continuing source to the basin. Sedimentation rates may have decreased since the basin stopped serving as a settling basin for the facility discharge line. The onsite basin may receive some soil erosion from the surrounding area, but the vegetative cover surrounding the basin limits erosion.

Methylmercury concentrations in the onsite basin sediment samples were 0.008 and 0.01 percent of mercury, somewhat lower than in the West Ditch and OU2 stream channel sediment samples. The reasons for this difference are not known.

The West Ditch, unlike the onsite basin, is likely to be a continuing source of mercury to OU2 through the Diamond Shamrock/Henkel Ditch (north), into which the West Ditch drains. All three of the surface water concentrations exceeded the SWQS. Also, all of the sediment concentrations exceeded the sediment screening criteria. It is likely that groundwater in the vicinity of the West Ditch is contributing to the high concentrations of mercury in surface water. The flow direction in the vicinity of the developed area (see Figures 3-4a, b, c, and d) and the mercury concentrations in the nearby wells suggest the groundwater discharge to the West Ditch may be a source of mercury in the surface water. The sediment data, however, suggest that little, if any sediment transport to OU2 from the West Ditch is occurring. While it is likely that some sediment transport in the West Ditch occurs during storm events, the concentrations decrease in the downstream direction, indicating that little sediment transport from upstream to downstream is occurring.

Methylmercury as a percentage of total mercury in West Ditch water ranged from 0.15 to 0.48 percent, an order of magnitude or more higher than in the OU2 or onsite basin surface water samples. The methylmercury concentrations in sediment samples as a percentage of total mercury, however, were in similar range to that found in samples from OU2 streambed and onsite basin sediment samples. This indicates either the presence of conditions favorable for mercury methylation in the West Ditch surface water or the relative absence of condition favorable for demethylation. Light and oxygen content tend to enhance demethylation.

OU2 Surface Water—Mercury concentrations were below the IDL ($0.2 \mu\text{g/L}$) in all but two of the filtered surface water samples, SW-02 ($0.24 \mu\text{g/L}$) and SW-03 ($0.2 \mu\text{g/L}$), both sampled at low tide. In those two samples, the filtered sample concentrations were 15 and 1.5 percent of the unfiltered sample concentrations, respectively. Mercury was detected in all unfiltered surface water samples. Some fraction of the particulate matter in these samples was naturally waterborne, and some may have been introduced during the sampling process through disturbance of the sediment. This large difference in concentration between the filtered and unfiltered samples indicates that, as expected, the

transport and fate of mercury in surface water is governed principally by the transport and fate of particulate matter.

In the Diamond Shamrock/Henkel Ditch (north), mercury concentrations in the unfiltered samples had a pronounced gradient, decreasing in the downstream direction (Figure 4-13). This pattern does not correspond to the sediment concentration pattern (uniform throughout the ditch) and could, therefore, indicate the presence of a continuing source to the surface water at the upstream end of the Diamond Shamrock/Henkel Ditch (north). The West Ditch was identified above as a potential source to the Diamond Shamrock/Henkel Ditch (north). The degree to which the West Ditch is a source to the Diamond Shamrock/Henkel Ditch (north) cannot be determined with the existing data because of the long time period between the sample collection events in the West Ditch and the Diamond Shamrock/Henkel Ditch (north). Mercury concentrations in the unfiltered surface water samples from Berry's Creek did not exhibit a clear pattern, except that concentrations in low tide samples taken north of the tide gate were higher than from low tide sample taken south of the tide gate. This pattern does not correspond with the sediment concentrations (Figure 4-1).

In OU2 surface water samples, dissolved methylmercury as a percentage of dissolved total mercury could be calculated for only two samples, the low tide samples at SW-03 and SW-04, because the dissolved mercury concentrations were below the IDL (Figures 2-2 and 4-14). These percentages were both between 0.1 and 0.2. Total methylmercury concentrations as a percentage of total mercury concentrations varied only from 0.05 to 0.1, while the total mercury varied by more than an order of magnitude, from 0.74 to 15.6 $\mu\text{g/L}$, indicating that factors other than the total mercury concentration are controlling the methylmercury concentration. Methylmercury as a percentage of total mercury values were in a similar range to those found in the other sampled surface water bodies, except the West Ditch, in which the methylmercury percentage of total mercury was nearly an order of magnitude higher.

OU2 Sediment—Two sediment samples were collected for mercury analysis at each station, one from the 0- to 2-cm depth horizon, and one from the 0- to 15-cm depth horizon. The 0- to 2-cm horizon represents the potentially oxic sediment, and these samples were analyzed for mercury only; the 0- to 15-cm horizon is expected to be principally anoxic. Both depth horizons were analyzed for mercury but only the 0- to 15-cm horizon was analyzed for methylmercury. Data from the Diamond Shamrock/Henkel Ditch (north) and Berry's Creek are discussed below.

Diamond Shamrock/Henkel Ditch (north) Sediments—Mercury in these sediments is not likely related to localized continuing sources from the undeveloped filled area along the Diamond Shamrock/Henkel Ditch (north). In the Diamond Shamrock/Henkel Ditch (north), the mercury concentrations in the 0- to 2-cm and 0- to 15-cm horizons were all in the range of 57 to 98 mg/kg, and five of the six values from these three locations were in the range of 57 to 70 mg/kg. The methylmercury concentrations were also similar, with values at SD-05 and SD-06 being essentially equal (0.012 mg/kg), and the value at SD-07 (0.02 mg/kg) slightly less than twice as high as those values. As a percentage of

mercury, methylmercury concentrations ranged from 0.018 to 0.029 percent, a similar range to that found in other streambed sediments. The uniformity of these measured mercury concentrations, both laterally and vertically, indicates that mercury in the ditch sediment may be related to conditions that affect the entire ditch uniformly and remain stable for an extended time period.

Berry's Creek Sediment—In Berry's Creek, mercury concentrations in sediment were more variable than in either the Diamond Shamrock/Henkel Ditch (north) or the onsite basin. Mercury concentrations in the 0- to 2-cm horizon were higher than in the 0- to 15-cm horizon at all three stations downstream of the Site (SD-02, -03, and -04). There was also a mercury sediment concentration gradient decreasing from upstream to downstream in these three 0- to 2-cm samples (11,100 mg/kg at SD-02; 223 mg/kg at SD-03; 0.89 mg/kg at SD-04). In the 0- to 15-cm samples, stations SD-02 (69.6 mg/kg) and SD-03 (70 mg/kg) had nearly identical mercury concentrations, at about twice the concentration in SD-01 (33.8 mg/kg). Mercury was not detected in the 0- to 15-cm sample at SD-04. In the upstream station, SD-01, the 0- to 2-cm (31.3 mg/kg) and 0- to 15-cm (33.8 mg/kg) mercury concentrations were nearly identical.

Methylmercury concentrations at stations SD-01, -02, and -03 varied from only 0.008 to 0.01 mg/kg, a smaller range of variation than found for mercury. Methylmercury concentrations as a percentage of mercury ranged from 0.01 to 0.03, similar to the range of values measured in other streambed sediment samples.

Marsh Area—Samples from the marsh area were termed soil samples in the Work Plan (CRA 1996), but may also be considered as sediment, because they are usually wet throughout the tidal cycle. The Phase I data indicate that the marsh area has accumulated higher mercury concentrations than the Creek and ditch sediments, except for the 0- to 2-cm sample at SD-02 in Berry's Creek. The geometric mean concentration for the marsh-area samples is higher than all but two of the streambed sediment mercury concentrations. These data are not, however, directly comparable, because the sediment was sampled from the 0- to 15-cm horizon (0–6 in.), while the marsh soil was sampled from the 0- to 2-ft horizon (with larger roots/tubers removed).

Methylmercury concentrations at marsh area stations ranged from 0.004 to 0.22 mg/kg. Methylmercury concentrations as a percentage of mercury were similar to the range of values calculated for other streambed sediment samples.

Summary—The substantial differences between mercury concentrations in the filtered and unfiltered samples combined with the presence of mercury in all but one of the sediment samples indicates, as expected, that mercury in surface water associates with particulate matter. The fate of mercury in surface water and sediment, therefore, is primarily a function of the physical fate of particles.

In OU1, the onsite basin is not likely to be a continuing source of mercury migration away from the basin, but the West Ditch may be a continuing source of mercury to the Diamond Shamrock/Henkel Ditch (north).

Mercury in sediments in the Diamond Shamrock/Henkel Ditch (north) and the onsite basin are uniformly distributed, possibly indicating a lack of localized continuing sources of mercury to sediments in these areas. The pattern of mercury in the Diamond Shamrock/Henkel Ditch (north) surface water samples, however, does indicate the potential presence of a continuing source to surface water. Mercury concentrations in Berry's Creek sediment were much more variable than in any of the other surface water bodies.

Mercury methylation rates, as judged by methylmercury as a percentage of total mercury, are fairly consistent among all the streambed samples and among all the surface water samples, except the West Ditch surface water samples. Mercury methylation rates were much lower in the marsh area sediment than in the streambed sediment. There are, however, no standard criteria by which to judge the significance of methylmercury concentrations. Rather, the behavior and impact of methylmercury in the ecosystem should be evaluated to assess the significance of the methylmercury concentrations. Such evaluation, if needed, may be part of the ecological risk assessments for the marsh area and Diamond Shamrock/Henkel Ditch (north) in this RI/FS, and for Berry's Creek in the subsequent basin-wide RI/FS. In surface water, methylmercury is expected to be short-lived, because it is subject to demethylation, forming elemental mercury, which volatilizes from the water. Methylmercury may also be subject to demethylation in sediments, forming mercuric sulfide, which is highly insoluble and chemically stable, and dimethylmercury, which volatilizes.

5.2.4 Air

Concentrations of gaseous mercury were measured in air at the Site at 16 locations over three sampling periods during the remedial investigation and were well below the NJDEP building interior air standard of 300 ng/m³. Volatilization can therefore be considered an insignificant pathway for mercury transport from the Site.

Mercury on fugitive dust is also not expected to be an issue at this Site, because the ground cover (pavement and buildings in the developed area, thick vegetation in the undeveloped filled area, and thick vegetation and water in the marsh) should prevent significant fugitive dust formation. The Site data confirm this expectation, with a maximum particulate mercury concentration of 1.66 ng/m³.

5.3 Other Metals

5.3.1 Soil, Groundwater, and Seeps

This section discusses leaching from soil to groundwater, and potential migration in groundwater for the groundwater and seep metal SoPCs that exceeded GWQS and MCL

values (antimony, arsenic, cadmium, iron, lead, manganese, nickel, sodium, and thallium) and potential impacts to surface water for those that exceeded SWQS values (arsenic, lead, selenium, and thallium). Copper, lead, and zinc were identified as SoPCs for offsite soils.

Antimony—Antimony was not detected in Phase I groundwater samples (detection limit of 3.4 $\mu\text{g/L}$) and was not analyzed in Phase IA groundwater samples. However, antimony was reported in the NJDEP groundwater data from 1991 where it exceeded the MCL and equaled the SWQS in the filtered sample from MW-8, exceeded the MCL and GWQS in the unfiltered sample from MW-7, and exceeded the MCL and SWQS in the unfiltered sample from MW-12. None of the seep samples contained antimony at concentrations exceeding the GWQS, SWQS or MCL. Antimony was detected in most subsurface soil samples (maximum of 41.2 mg/kg, Site-wide arithmetic mean of 6.5 mg/kg; Table B3-2) at concentrations well below the NRDCSCC (340 mg/kg) but above the SSL for migration to groundwater (0.3 mg/kg). The groundwater data indicate that antimony has very limited potential for leaching to soil from groundwater at this Site, and the seep data indicate that antimony is not migrating to surface water in concentrations above the SWQS or MCL.

Arsenic—Arsenic concentrations in groundwater and seeps exceeded GWQS values in Phase I at MW-6, in Phase IA at MW-13 and MW-14, and in Phase IA SFI at MW-6, MW-13, and MW-14. Arsenic concentrations exceeded SWQS in Phase I at MW-6 and in Phase IA at seeps SE-01A and SE-06A. Arsenic was not detected in the Phase IA sample from MW-6. Arsenic concentrations in soil were relatively high in the 10- to 12-ft depth interval at MW-6. For MW-14, soil samples from MW-14 and a nearby test pit (TP-01) were relatively high. In contrast, none of the soil arsenic concentrations near MW-13 are particularly elevated. Also, there are no notable elevated arsenic concentrations near seeps SE-01A or SE-06A. The factors controlling arsenic mobility in groundwater are complex, and local geochemical conditions could account for some of the variability in groundwater and seep concentrations. The data, therefore, indicate that there is some potential for arsenic migration to surface water at concentrations above the SWQS, but further study would be needed to reveal the factors that control arsenic mobility in groundwater at this Site.

Cadmium—Cadmium concentrations in groundwater and seeps exceeded GWQS and MCL values in Phase I at SE-02 and in Phase IA at MW-5, while cadmium concentrations did not exceed SWQS values in any samples. Cadmium concentrations did not exceed the GWQS, SWQS, or MCL in any of the Phase IA SFI groundwater samples. Cadmium concentrations in TP-15, which is near SE-02, are relatively high compared to other test pits near seep sample locations, and could be related to the cadmium in SE-02. There are no notably elevated cadmium soil concentrations, however, near MW-5. The data, therefore, do indicate some potential for limited mobility of cadmium in groundwater, but not at a level sufficient to negatively impact surface water.

Iron and Manganese—Iron and manganese both exceeded the GWQS in nearly all groundwater samples in both Phases I and IA. These results are typical in reducing conditions. Both iron and manganese are common components of soil, and, under reducing conditions, they form soluble species that can be leached from the soil (Chapelle 1993). Iron and manganese, therefore, have the potential to leach from soil to groundwater and migrate in Site groundwater. The average oxidation-reduction potential was higher (less reducing) in Phase IA than in Phase I. The general reduction in groundwater iron concentrations between Phase I and Phase IA could be related to this change in average geochemical conditions.

For seeps, in contrast to groundwater samples, the GWQS for manganese was exceeded in all five filtered seep samples, while the criterion for iron was exceeded in only one filtered sample (SE-04). Further, iron concentrations in seeps were generally an order of magnitude or more lower than in groundwater, while manganese concentrations were of similar magnitude in groundwater and seeps. This indicates that dissolved iron concentrations are attenuating significantly between the wells and the seeps, while the manganese concentrations are not.

Iron concentrations in the filtered seep samples were an order of magnitude or more lower than in the groundwater samples from wells along the Site perimeter with Berry's Creek and the Diamond Shamrock/Henkel Ditch (north), except for MW-12. In MW-12, the iron concentration was only twice as high as the highest dissolved concentration in a seep sample. The iron concentration decreases between groundwater and filtered seep samples may be due in part to the oxygenation and consequent formation of relatively insoluble iron compounds that is expected to occur when the groundwater emerges from the bank. The difference may also be due in part to groundwater mixing with exfiltrating surface water, in which the iron concentrations are also much lower than in groundwater.

Manganese concentrations generally decreased from groundwater samples to filtered seep samples to filtered surface water samples, but the decreases were not as consistent or pronounced as for iron. Dissolved manganese concentrations in the perimeter wells adjacent to surface water bodies ranged from 361 to 3,840 $\mu\text{g/L}$, while manganese concentrations in seeps ranged from 200 $\mu\text{g/L}$ to 1,660 $\mu\text{g/L}$. Manganese concentrations in filtered surface water samples, excluding the onsite basin, were somewhat lower than in filtered seep samples, ranging from 15 to 948 $\mu\text{g/L}$. The formation of relatively insoluble compounds described above for iron also occurs for manganese, but at a slower rate than for iron.

For iron, these relations indicate the potential for migration from the undeveloped filled area to the adjacent surface water bodies, but with subsequent formation of relatively insoluble compounds in surface water. For manganese, these relations indicate the potential for net migration of dissolved manganese from the Site to the adjacent surface water. There are not, however, any SWQS or MCLs for iron or manganese.

Lead—Lead concentrations in groundwater and seeps exceeded the GWQS only in the Phase IA sample from MW-15, while lead concentrations exceeded the SWQS in four

wells from Phase IA, MW-6, MW-8, MW-12, and MW-15. The Phase IA lead concentration in MW-15, however, may not be representative of groundwater because of the high turbidity in the sample. This issue was discussed in Section 4. Lead concentrations did not exceed the GWQS, SWQS, or MCL in any of the Phase IA SFI groundwater samples. There are some relatively high soil lead concentrations in several test pit samples from the vicinity of MW-6 and from one soil sample in the vicinity of MW-8, but there are no notably elevated soil lead concentrations in the vicinity of MW-12 or MW-15 (Figure 4-4). The groundwater data, therefore, indicate some potential for lead to leach from soil in concentrations above the SWQS, but the seep data indicate that those concentrations are attenuating to below the SWQS between the well locations and the creek banks.

Nickel—Nickel concentrations in groundwater and seeps exceeded the GWQS in Phase I in MW-6, but did not exceed either the GWQS or SWQS in any other Phase I or Phase IA groundwater or seep samples. There is one moderately elevated soil nickel concentration in TP-05, just south of MW-6, but no other notably elevated soil nickel concentrations in the vicinity of MW-6 (Figure 4-11). The groundwater data, therefore, indicate that nickel has very limited potential for leaching from soil to groundwater at this Site, and the seep data indicate that nickel is not migrating to surface water in concentrations above the SWQS.

Selenium—Selenium concentrations in groundwater and seeps exceeded the SWQS in Phase IA in the sample from SE-03a, but did not exceed the SWQS in any other groundwater or seep sample from either Phases I or IA. Since none of the groundwater samples exceeded the SWQS, it is difficult to determine whether the SWQS exceedances in SE-03a was due to migration in groundwater or to dissolution of selenium by surface water that infiltrates the creek bank during high tide. The groundwater data indicate that selenium does not leach from OU1 soils at concentrations above the SWQS, but one seep sample did indicate a small potential for migration from OU1 to Berry's Creek at concentrations above the SWQS.

Sodium—Sodium concentrations exceeded the GWQS in 7 of the 12 Phase I groundwater samples and in all 5 of the Phase I seep samples. These data indicate that sodium may leach from soil to groundwater at concentrations above the GWQS. The seep concentrations, however, were more than an order of magnitude higher than the groundwater samples, indicating a sodium source other than Site soils. Sodium concentrations in OU2 surface water samples were generally in the same range as the sodium concentrations in seep samples, indicating that the surface water is most likely the primary source of sodium to the seep samples.

Thallium—Thallium concentrations in groundwater and seep samples exceeded the GWQS in Phase IA in MW-2, while concentrations exceeded the SWQS and MCL in Phase I at MW-3 and MW-6 and in Phase IA at MW-5. Thallium concentrations did not exceed the GWQS, SWQS, or MCL in any of the seep samples or in the Phase IA SFI groundwater samples. The groundwater data, therefore, indicate some potential for leaching from soil to groundwater in concentrations exceeding the GWQS or SWQS, but

the seep data indicate that these concentrations attenuate to below the SWQS before they reach the creek bank.

Offsite soils—Copper, lead, and zinc were all delineated to below the RDCSCC values in offsite soils. It is difficult to evaluate the sources and migration pathways for these metals at the offsite soil sample locations because of the wide range of potential sources in the Site vicinity.

Summary—The groundwater and seep data indicate that the only SoPCs that have potential to migrate to surface water at concentrations greater the SWQS are arsenic and selenium, and the potential appears very limited for both of those. Iron and manganese are likely to be migrating from the undeveloped filled area to the adjacent surface water bodies, but there are no SWQS values for iron and manganese.

5.3.2 Surface Water and Sediment

In OU1, only lead was identified as a SoPC for surface water. In OU2, arsenic, lead, and thallium were identified as SoPCs. For sediment, arsenic, cadmium, chromium, copper, iron, lead, nickel, silver, and zinc were identified as SoPCs for both OU1 and OU2. This section discusses the behavior of these SoPCs with respect to their tendency to associate with particulate matter and their distribution in sediment.

Surface Water—Metal SoPCs in surface waters are expected to be associated principally with particulate matter. The data confirm this expectation strongly for arsenic and lead, but less clearly for thallium. In OU2, arsenic and lead did not exceed the SWQS in filtered samples. Also, for arsenic, two of the three exceedances in unfiltered samples were at SW-04, the furthest downstream sample location. The third exceedance was at SW-05, the most upstream sample in the Diamond Shamrock/Henkel Ditch (north). For thallium, the differences between the filtered and unfiltered concentrations for the two unfiltered and one filtered samples in which thallium was detected, were not as great as the differences between filtered and unfiltered sample concentrations for arsenic and lead. In OU1, filtered surface water samples were not analyzed.

Sediment—In contrast to surface water, nine metals were identified as SoPCs for sediment. The presence of these nine metal SoPCs in sediment does not, however, appear to be causing surface water quality screening criteria to be exceeded. Of these nine, only lead in OU1 and arsenic and lead in OU2 exceed SWQS values, and then only for unfiltered samples. The patterns of concentration in the sediment are discussed briefly below, though it must be recognized that there may be many sources for the sediment SoPCs other than the Site.

The concentrations of six of the nine sediment SoPCs (cadmium, chromium, copper, lead, silver, and zinc) in Berry's Creek were an order of magnitude lower in the furthest downstream sediment sample (SD-04) than in the samples from locations adjacent to the Site (SD-01, SD-02, and SD-03). For the other sediment SoPCs (arsenic, iron, and

nickel) concentrations at SD-04 were similar in magnitude to concentrations adjacent to the Site. This indicates that OU1 has a lesser potential to be a significant source of arsenic, iron, and nickel to the streambed sediments than for the other sediment SoPCs.

Concentrations of arsenic, cadmium, chromium, copper, nickel, and silver in sediment increased going downstream in the Diamond Shamrock/Henkel Ditch (north). Iron and lead did not show a clear trend. In contrast to most of the other metal SoPCs, concentrations of zinc in sediment decreased in the downstream direction. The highest concentration in sediment for each of the metal SoPCs, except for mercury and zinc, was found in the sample from SD-07, near the confluence of the Diamond Shamrock/Henkel Ditch (north) and Berry's Creek.

The highest cadmium concentration was at SD-07, which is in the vicinity of the seep with the highest cadmium concentration, SE-02. These data indicate the potential for a localized source from the Site in the vicinity of sample station SD-07 and SE-02.

Zinc sediment concentrations in the Diamond Shamrock/Henkel Ditch (north) were an order of magnitude higher than the concentrations elsewhere and had a pronounced gradient. The concentrations were 7,300 mg/kg at SD-05, (closest to the Diamond Shamrock/Henkel facility), 4,640 mg/kg at SD-06, and 2,640 mg/kg at SD-07 (closest to Berry's Creek). A possible explanation for this pattern is a source of zinc at the upstream end of the Diamond Shamrock/Henkel Ditch (north). IT (1988) reports concentrations of zinc in soils at numerous locations on the Diamond Shamrock/Henkel facility that are an order of magnitude greater than those measured on Site. The zinc concentration at SD-04 was an order of magnitude lower than the concentration at the other locations in Berry's Creek. At the upstream sample locations in Berry's Creek, zinc sediment concentrations fell within a tight range, from 602 to 792 mg/kg. These data suggest either that there are no localized sources along Berry's Creek or that tidal action rapidly redistributes any localized contributions.

Summary—The presence of the nine metals identified as SoPCs in sediment is not causing surface water screening criteria to be exceeded in the vicinity of the Site, except possibly for lead in OU1 and arsenic and lead in OU2.

5.3.3 Air

Metals in air are not expected to be an issue at this Site, because the ground cover (pavement and buildings in the developed area, thick vegetation in the undeveloped filled area, and thick vegetation and water in the marsh) should prevent significant formation of fugitive dust. The low concentrations of mercury in particulate air samples support this expectation.

5.4 SVOCs and PCBs

5.4.1 Soil, Groundwater, and Seeps

One PAH and DEHP were identified as SoPCs in surface soils, three PAHs and DEHP were identified as SoPCs in subsurface soils, and six PAHs were identified as SoPCs in offsite soils. Soil, groundwater, and seep samples were not analyzed for PCBs.

PAHs—The undeveloped filled portion of the Site is not expected to be a significant source of PAHs to the groundwater or surface water adjacent to the Site. Concentrations of all PAHs identified as SoPCs in the soil were below IDLs in all groundwater, seep, and surface water samples. These results confirm their expected low mobility in water. PAHs have a strong tendency to sorb to particles and have generally low solubility (Neff et al. 1994). The strength of their tendency to adsorb to particles generally increases, and their aqueous solubility generally decreases, with increasing molecular weight. This sorption is governed largely by the affinity of PAHs for organic matter. In most soils, therefore, and particularly in high-organic-content soils, PAHs tend to have very low mobility in groundwater.

Low levels of PAHs are ubiquitous in onsite soils, but only benzo[a]pyrene (BaP) exceeds the NRDCSCC in more than 5 of the Site soil samples (surface and subsurface combined). BaP exceeds the screening criterion in 21 of the 74 onsite soil samples analyzed for BaP.

Offsite PAH concentrations generally are higher than those on the Site, especially in the samples collected farthest from the Site boundary. Table 4-3b and 4-3c summarize the concentrations adjacent to and not adjacent to the Site. The mean values not adjacent to the Site range from 1.3 to 2.1 times higher than the mean values adjacent to the Site, and the maximum values not adjacent to the Site are approximately an order of magnitude higher. Further, the mean values for even the samples adjacent to the Site are higher than the mean values for the onsite surface soil samples. The offsite soil PAHs in the area north of Ethel Boulevard, therefore, are not likely to be related to the Site (Figure 4-8).

Further, with the exception of benzo[b]fluoranthene, the mean values of the PAHs in offsite soils (Table 4-3a) are lower than the mean values reported for urban soils by Bradley et al. (1994) and Neff et al. (1994), as shown in Table 5-3. For benzo[b]fluoranthene, the arithmetic mean concentration from samples adjacent to the Site (1,300 $\mu\text{g}/\text{kg}$) is lower than the arithmetic mean reported by Bradley et al. (1994) (1,435 $\mu\text{g}/\text{kg}$).

DEHP—DEHP is a common component of plastics and paints. It is also the breakdown product of a wide range of organic compounds. It is ubiquitous in onsite and offsite soils and is a common laboratory contaminant. It was identified as a SoPC due to exceedance of the ecological soil screening criterion in one sample, from SS-18. The second highest concentration, at SS-24, was about 25 percent lower than at SS-18, but the third highest

concentration, at SS-17, was an order of magnitude lower than at SS-24. SS-17, SS-18, and SS-24 are located just south of the Wolf Warehouse and southeast of the Randolph Products property.

DEHP mobility in the groundwater is expected to be similar to that of PAHs because the octanol/water partition coefficient of DEHP is in the same range as for many PAHs. DEHP concentrations did not exceed the GWQS in any well or seep samples, but did exceed the SWQS in one downgradient perimeter well sample, from MW-06, and in two Phase I seep samples, SE-02 and SE-03. DEHP was not analyzed in the Phase IA seep samples. Seeps SE-02 and SE-03 are not downgradient from the three soil samples with the highest DEHP concentrations, so the presence of DEHP in those seep samples may be due to distributed lower concentration sources. These groundwater and seep data indicate that DEHP does have some potential to leach from soil into groundwater and migrate to surface water bodies at concentrations greater than the SWQS.

5.4.2 Surface Water and Sediment

No organic SoPCs were identified for OU1 surface water, while DEHP was identified as a SoPC for OU2 surface water. PCBs were not measured in surface water. Thirteen PAHs and two PCB Aroclors[®] were identified as SoPCs for OU1 sediment, while those plus three additional PAHs were identified as SoPCs for OU2 sediment. The strong tendency for PAHs to partition to solid-phase materials, described above for groundwater and soil, also applies in surface water and sediment, and it also applies to PCBs. PCBs and high-molecular-weight PAHs have a similar level of affinity for adsorption to organic matter, which in surface water bodies is most often associated with particles. As with metals, therefore, PAH and PCB transport in surface water bodies is expected to be related to sediment movement.

Surface Water—DEHP exceeded the SWQS in three samples and the DEHP in OU2 surface water could be related to sources from OU1 and could also be related to a wide variety of other potential sources for DEHP in the environment.

Sediment PAHs—PAHs could potentially migrate from OU1 to the adjacent surface water bodies through soil erosion. As discussed earlier, however, there is no evidence of significant soil erosion from the Site to the adjacent surface water bodies. Additionally, this segment of Berry's Creek and the Diamond Shamrock/Henkel Ditch (north) may accumulate PAHs from offsite sources in the Berry's Creek basin.

Sediment PCBs—The pattern of occurrence for PCBs in sediment suggests that the Site is not the source for the PCBs in OU2 sediments, but that Site soils may have contributed some PCBs to OU1 sediments. Two PCB Aroclors[®], 1248 and 1260, were detected in sediments. Concentrations of Aroclor[®] 1248 were significantly higher than for Aroclor[®] 1260 in most samples.

OU1—In the onsite basin, PCB concentrations at SD-08 were 240 $\mu\text{g/kg}$ for Aroclor[®] 1248 and 490 $\mu\text{g/kg}$ for Aroclor[®] 1260, while at SD-09, concentrations were 190 $\mu\text{g/kg}$ for Aroclor[®] 1248 and 260 $\mu\text{g/kg}$ for Aroclor[®] 1260. These values are somewhat greater than the regional background sediment concentrations for total Aroclor[®] of 250 $\mu\text{g/kg}$, reported by Iannuzzi et al. (1995) for Newark Bay and its tributaries (including the Hackensack River), but substantially lower than the concentrations in Berry's Creek and the Diamond Shamrock/Henkel Ditch (north).

Sediment from the Diamond Shamrock/Henkel facility production pond was reported to have total PCB concentrations ranging from 8,600 to 120,000 $\mu\text{g/kg}$, and facility soils were reported to have total PCB concentrations up to 820,000 $\mu\text{g/kg}$, with the highest concentrations being measured at a location adjacent to the Randolph products facility (IT 1988).

During the 1990-1991 NJDEP investigation, soil samples from the well borings were analyzed for PCBs (NJDEP 1993a). PCBs were reported at various depths in five soils samples, from four locations (MW-2, MW-5, MW-7, and MW-9). PCBs were reported in surface soils (0- 2-ft interval) only at MW-7. Only one Aroclor[®] was reported in each sample. Reported Aroclors[®] included 1242, 1248, 1254, and 1260 (two samples). All concentrations were below 1,000 $\mu\text{g/kg}$ except for the value of 4,400 $\mu\text{g/kg}$ of Aroclor[®] 1248 in the surface soil sample from MW-7. MW-7 is approximately 100-ft north of the onsite basin.

The Site history does not indicate any PCB use at the Site. The onsite basin may have been a settling basin for the former WRCC facility, and may also have served the same role for the Randolph Products facility (see Section 2 of the BITM, Volume 4). It also currently receives surface runoff from portions of the undeveloped filled area. These data indicate that the source of PCBs to the onsite basin was a combination of Site soils and offsite sources. Approximately half of the total PCB concentration in the onsite basin, however, may be attributable to regional background sources.

OU2—Concentrations of Aroclor[®] 1248 in Berry's Creek did not follow an identifiable pattern. They were similar in SD-01 (3,100 $\mu\text{g/kg}$) and SD-03 (4,500 $\mu\text{g/kg}$), but were below the IDL (33 $\mu\text{g/kg}$) in SD-02 and SD-04. In the Diamond Shamrock/Henkel Ditch (north), the concentrations show a gradient, increasing in the downstream direction. Concentrations of Aroclor[®] 1248 at stations SD-05 (1,400 $\mu\text{g/kg}$) and SD-06 (1,800 $\mu\text{g/kg}$) were similar, while the concentration at SD-07 (4,700 $\mu\text{g/kg}$) was significantly higher, approximately equal to the highest concentration in Berry's Creek (at SD-03). Aroclor[®] 1260 was detected at SD-03 (320 $\mu\text{g/kg}$) and SD-07 (430 $\mu\text{g/kg}$).

The source of the PCBs in the Diamond Shamrock/Henkel Ditch (north) is also uncertain. The Diamond Shamrock/Henkel facility, however, is a potential source of PCBs to the sediment. Additionally, this segment of Berry's Creek and the Diamond Shamrock/Henkel Ditch (north) may accumulate PCBs from offsite sources in the Berry's Creek basin.

5.4.3 Air

Similar to metals, windblown dust is the primary mechanism for PAH and PCB movement through the air pathway. This is due to the extremely low volatility of these compounds, and their strong association with organic particles in soils. Fugitive dust in air is not expected to be an issue at this Site, because the ground cover (pavement and buildings in the developed area, thick vegetation in the undeveloped filled area, and thick vegetation and water in the marsh) should prevent significant fugitive dust formation. The low concentrations of mercury in particulate air samples support this expectation.

5.5 VOCS

5.5.1 Soil, Groundwater, and Seeps

Five VOCs (benzene, chlorobenzene, 1,2-dichloroethene isomers, toluene, and xylenes) were identified as SoPCs in groundwater, but none were identified for soils or seeps. Except for benzene, the VOC GWQS exceedances appear to be very localized, and, based on the seep concentrations, VOCs in groundwater apparently attenuate before the Site boundaries are reached. The Site, therefore, is not expected to be a significant source of VOCs to groundwater or to the adjacent surface water bodies.

The VOCs identified as SoPCs for groundwater were detected in only a few soil samples (Tables 4-1a through c and 4-3a through d), while exceedances of one or more screening criteria values were distributed over several wells in Phases I and IA (MW-1, MW-2, MW-5, MW-7, MW-8, MW-9, MW-13, and MW-15). Benzene was the most frequently detected VOC in soils, being detected in six surface and five subsurface soil samples. Toluene was the next most widely detected, being found in three surface and four subsurface soil samples. Xylenes were detected in three subsurface and no surface soil samples, while chlorobenzene was detected in one subsurface and one surface soil sample. 1,2-Dichloroethene was not detected in any soil samples.

Three of soil samples in which benzene was detected were in the developed area along Ethel Boulevard, where benzene concentrations in surface soils ranged from 5 to 28 $\mu\text{g}/\text{kg}$. Two others were from TP-13, where benzene, ethylbenzene, toluene, and xylenes were found. Concentrations in these two samples were 8 and 10 $\mu\text{g}/\text{kg}$ benzene, 190 and 310 $\mu\text{g}/\text{kg}$ ethylbenzene, 70,000 and 23,000 $\mu\text{g}/\text{kg}$ toluene, and 110,000 and 22,000 $\mu\text{g}/\text{kg}$ total xylenes.

TP-13 is approximately 200 ft south of MW-2, one of the two wells at which benzene was measured above the IDL, and the only well at which toluene, xylenes, and ethylbenzene were measured above the IDL. TP-13, however, is most likely downgradient of MW-2, based on the piezometric head measurements described in Section 3.6.2. Therefore, the source of the VOCs in MW-2 is uncertain. Similarly, the

source of the benzene in MW-7 also is uncertain. The concentrations measured in soils along Ethel Boulevard are not high enough to account for the water concentration in MW-7, and the soil samples are most likely not upgradient of MW-7. Regardless of the sources, these VOCs have attenuated to below IDL values at all the wells around the perimeter of the undeveloped filled area, and were also below IDL values in all seep samples. There are no surface water criteria for these SoPCs.

Further, under oxic conditions, these compounds will degrade readily. Therefore, when these compounds are transported to oxic surface water, they will degrade rapidly or volatilize. Under anoxic conditions, toluene and xylene compounds can degrade biotically to benzoic acid, and subsequently to CO₂ and methane (Chappelle 1993).

5.5.2 Surface Water and Sediment

No VOCs were identified as SoPCs in OU1 surface water, and 1,1,2,2-tetrachloroethane was identified as a SoPC in OU2 surface water, based on one sample in which 1,1,2,2-tetrachloroethane was detected, and exceeded the SWQS. 1,1,2,2-Tetrachloroethane was not detected in any of the Site soil samples, surface or subsurface. It is difficult, therefore, to speculate on the source or migration pathway to surface water based on the available data.

5.5.3 Air

VOC compounds present in soil will volatilize into air. However, given the low concentrations of VOCs in soils, this process is not likely to be significant at the Site.

6.0 Human Health Risk Assessment

To be provided under separate cover.

7.0 Ecological Risk Assessment

To be provided under separate cover.

8.0 Summary and Conclusions

The objectives of this remedial investigation were to identify SoPCs and characterize their sources, spatial distribution, transport, and fate. The remedial investigation was conducted in accordance with the approved Work Plan, and the objectives were met.

8.1 Summary

8.1.1 Nature and Extent of Contamination

This section summarizes the nature and extent of contamination in terms of the SoPCs identified. Table 1-1 provides a complete list of SoPCs, Tables 4-1 through 4-7 provide summaries of the media specific SoPC concentrations and criteria values, and Appendix B provides complete data tables and criteria values.

- The SoPCs identified for OU1 included 20 metals, 5 VOCs, 15 SVOCs, and 2 PCB Aroclors[®].
- The SoPCs identified for OU2 included 10 metals, 1 VOC, 17 SVOCs, and 2 PCB Aroclors[®].
- Of the 17 groundwater SoPCs (OU1), 7 exceeded a GWQS value in only one well (cadmium, lead, nickel, thallium, xylenes, 1,2-dichloroethene, and toluene), 1 exceeded a GWQS value in only two wells (chlorobenzene), and 2 (arsenic and mercury) exceeded a GWQS value in only four wells. GWQS exceedances of iron, manganese, sodium, and benzene were more widespread. Two SoPCs (selenium and DEHP) exceeded their SWQS criteria values in only one sample each, (DEHP in Phase I and selenium in Phase IA). Mercury, thallium, lead, and benzene each exceeded SWQS values in more than one well. Antimony, cadmium, and toluene exceeded MCLs in only one well while MCL exceedances for benzene, mercury, and thallium were more widespread.
- For mercury, the GWQS and MCL exceedances all occur in or immediately adjacent to the developed area of OU1 (e.g., area of wells MW-7, MW-9, MW-13 and MW-15). Except in well MW-13, these exceedances occurred only in unfiltered groundwater samples, with filtered sample results generally an order of magnitude lower. The data indicate that dissolved phase mercury in groundwater in excess of the GWQS and MCL is generally localized to the northwest portion of

the developed area and limited in extent (i.e., limited migration onto the undeveloped area).

- Mercury-contaminated soils are likely to be present beneath the Wolf Warehouse, as part of the entombment plan conducted with oversight by NJDEP and EPA in 1975.
- Of the seven SoPCs identified in filtered seep samples (OU1), mercury, arsenic, and DEHP concentrations exceeded SWQS values in two seeps each. Cadmium and iron exceeded GWQS values in one seep each. Manganese and sodium exceeded GWQS values in all seeps.
- Two SoPCs (mercury and lead) were identified for OU1 surface water, based on unfiltered samples. Mercury concentrations exceeded the SWQS in both the onsite basin and the West Ditch, while lead exceeded the SWQS in only the West Ditch.
- Six SoPCs (four metals, one VOC, and one SVOC) were identified for OU2 surface water, based on unfiltered samples. Mercury concentrations in the unfiltered samples exceeded the SWQS in every sample except one, the low tide sample at SW-04. The number of SWQS exceedances for the other SoPCs ranged between one and four of the 15 OU2 surface water samples.
- OU1 sediment SoPCs included 9 metals, 13 SVOCs, and 2 PCB Aroclors[®]. The SVOCs were all PAHs.
- OU2 sediment SoPCs included all of the OU1 sediment SoPCs and three additional PAHs.

8.1.2 Transport and Fate of SoPCs

This section summarizes the transport and fate in terms of the SoPCs identified.

- The regional flow pattern for shallow groundwater in the vicinity of the Site is toward Berry's Creek with groundwater discharge to Berry's Creek, its tributaries, and adjacent marsh areas. Site data show that groundwater mounding in the undeveloped filled area creates a radial flow pattern in that area (flow directed outward from approximately the center of the area), redirecting the flow that would normally result from the regional flow patterns. Where the undeveloped filled area is bordered by Berry's Creek and the Diamond Shamrock/Henkel Ditch (north), the shallow groundwater still discharges to those water bodies. On the northeast and northwest sides of the undeveloped filled area, the radial flow direction in the

undeveloped filled area is opposed to the regional flow direction. Where the radial groundwater flow from the undeveloped filled area meets the regional flow, the two systems merge and flow patterns are redirected accordingly, with the regional flow ultimately dominating. The result is that on the northeast side of the undeveloped filled area, shallow groundwater flowing radially from the undeveloped filled area is expected to turn to the east and discharge to Berry's Creek. Similarly, on the northwest side of the undeveloped filled area, the shallow groundwater flowing radially from the undeveloped filled area meets the regional flow in the southern portion of the developed area, turns to the west, and is expected to discharge to the West Ditch, and hence the Diamond Shamrock/Henkel Ditch (north). Consistent with these patterns, shallow groundwater from the developed area, therefore, is also expected to be discharging to the West Ditch, though some of the flow may also split off to the north side of the undeveloped filled area.

- The presence of a concrete wall to a depth of 3.5 ft bgs at two locations adjacent to the Wolf Warehouse is expected to have minimal effect on groundwater movement in the vicinity of the warehouse.
- SoPCs at this Site are associated with the soils, sediments, and suspended solids in water to a much greater extent than they are dissolved in groundwater or surface water. Movement of particulate matter, therefore, is likely to be the dominant mode of SoPC transport.
- Mercury was found above SWQS values in both developed area groundwater and the West Ditch, indicating the potential for mercury migration in groundwater to surface water in the West Ditch.
- Arsenic and mercury were found above SWQS values in OU2 surface water and in both filtered seep samples and in downgradient perimeter groundwater samples. This pattern indicates the potential for migration from OU1 to OU2 at rates great enough to have an impact on OU2 water quality. However, there are likely to be other sources, in addition to OU1, for these SoPCs in OU2 surface water. Two of the three SWQS exceedances for arsenic in surface water were at SW-04, well downstream of OU1, indicating that there are likely to be sources other than OU1.
- Lead, thallium, and DEHP were found above SWQS values in OU2 surface water and downgradient perimeter wells, but not in filtered seep samples, indicating that the migration of these SoPCs attenuates significantly between the downgradient perimeter wells and the creek bank.

- Selenium, benzene, and chlorobenzene were found in either filtered seep samples or downgradient perimeter groundwater samples at concentrations above SWQS values, but were not found in surface water at concentrations above SWQS values, indicating that the migration rate of these SoPCs from OU1 is not large enough to have a significant impact on OU2 surface water.
- The information available does not identify any significant pathways for ongoing SoPC migration from OU1 to offsite areas that are not part of OU2.

8.2 Conclusions

The principal transport-and-fate issues identified for OU1 (the developed area and the undeveloped filled area) are related to the potential for SoPCs from OU1 to migrate to the adjacent surface water bodies and the marsh area (OU2). OU2 is part of the contiguous tidal wetlands of Berry's Creek. The dominant pathways by which SoPC migration between OU1 and OU2 may potentially occur are migration in groundwater, migration in West Ditch surface water, and sediment/soil erosion along the creek bank and the transition zone to the marsh area. A potential pathway that is likely to be of lesser significance is surface water runoff during storm events carrying eroded soil particles or dissolved SoPCs picked up from the surface soil. Conclusions from the remedial investigation regarding two key issues, groundwater movement and migration from OU1 to OU2, are discussed below.

8.2.1 Groundwater Movement

The hydrology/hydrogeology of the Site is complex. Whereas the entire Site was once a marsh area and, consequently, a regional discharge area for groundwater, it now has three distinctly different hydrologic regimes. The pervious fill in the undeveloped filled area has created a local groundwater recharge area and associated groundwater mound, which creates a radial flow pattern from the center toward the perimeter of the undeveloped filled area, interrupting the regional flow toward Berry's Creek. The impervious surface cover in the developed area creates a zone with highly limited groundwater recharge, a zone in which the regional flow toward Berry's Creek and the radial flow from the undeveloped filled area meet. Specific flow patterns for these areas were discussed above in Section 8.1.2. The marsh area is expected to still be a local and regional groundwater discharge area. It is also part of the contiguous tidal wetlands of Berry's Creek. The presence of tidal fluctuations in Berry's Creek and connected water bodies, such as the marsh area and the Diamond Shamrock/Henkel Ditch (north), adds further complexity to the Site hydrology/hydrogeology. The tidal fluctuations, however, dissipate between the creek banks and the groundwater monitoring wells.

8.2.2 SoPC Migration from OU1 to OU2

Sediment quality data integrates contributions from all sources in the watershed over the period of time required to accumulate the sediment horizon that was sampled, including the recent past. Surface water data, to the contrary, provides an assessment predominantly of current contributions from all sources in the watershed. Surface water data can also, however, be affected by sediment quality through sediment resuspension, especially during periods of high flow or other disturbances.

OU1 may have been an historic source and may be a continuing source for SoPCs identified for the sediment. Any continuing source is likely to be predominantly through creek bank erosion, though contribution from surface soil erosion during storm events cannot be ruled out. Mercury and arsenic may also be migrating in groundwater from OU1 to OU2 at concentrations greater than the SWQS values. Based on the seep data, the other SoPCs found at concentrations greater than SWQS values in groundwater (selenium, thallium, lead, benzene, and DEHP) attenuate to below SWQS values before reaching the creek banks. The quantitative relative contributions of OU1 and other sources in the watershed, however, would be difficult, if not impossible, to determine. The air concentration data for mercury indicate that migration in air from OU1 is not a significant source.

For surface water, the remedial investigation data indicates that total current contributions from all sources are causing SWQS exceedances in OU2 surface water for arsenic, lead, mercury, thallium, 1,1,2,2-tetrachloroethane, and DEHP. Of these, only arsenic and mercury were found in filtered seep samples at concentrations exceeding the SWQS. For arsenic, however, two of the three SWQS exceedances were well downstream of OU1 (at SW-04), suggesting that the source causing those exceedances is not likely to be from OU1. Lead, thallium, and DEHP were found at concentrations exceeding the SWQS in groundwater, but not in filtered seep samples. 1,1,2,2-Tetrachloroethane was not detected in any OU1 samples from any media. Note that arsenic and lead concentrations did not exceed SWQS values in any filtered OU2 surface water samples.

Based on these data, only mercury cannot be ruled out as unlikely to be migrating from OU1 to OU2 at rates high enough to cause SWQS exceedances in OU2 surface water. Even for mercury, there are likely to be other sources of mercury in OU2 water, including atmospheric deposition from regional and national sources, and other potential sources in the watershed. Further assessment of conditions over a broader area of the Berry's Creek watershed, however, will be needed to evaluate the sources contributing to the SWQS exceedances in OU2 surface water.

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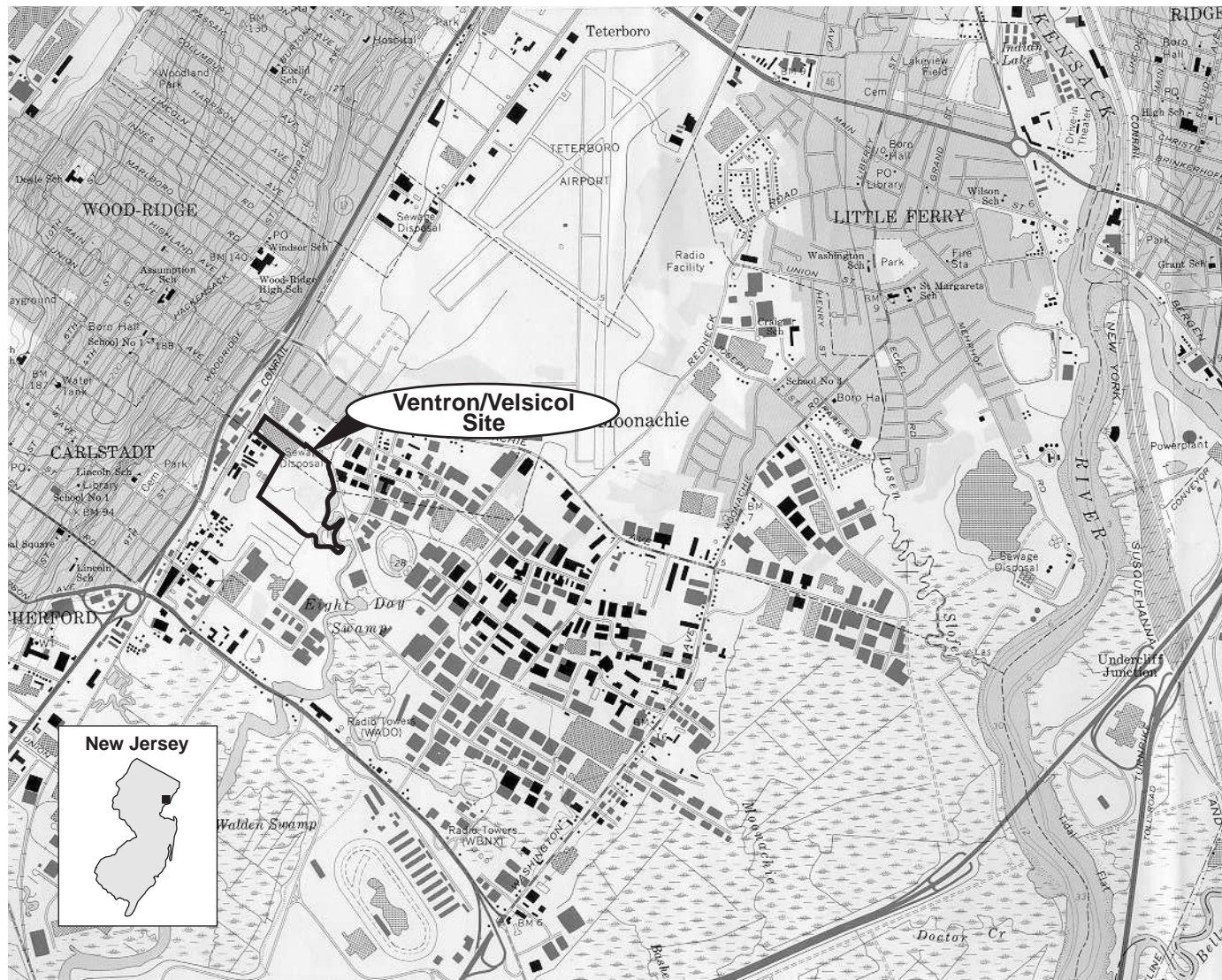
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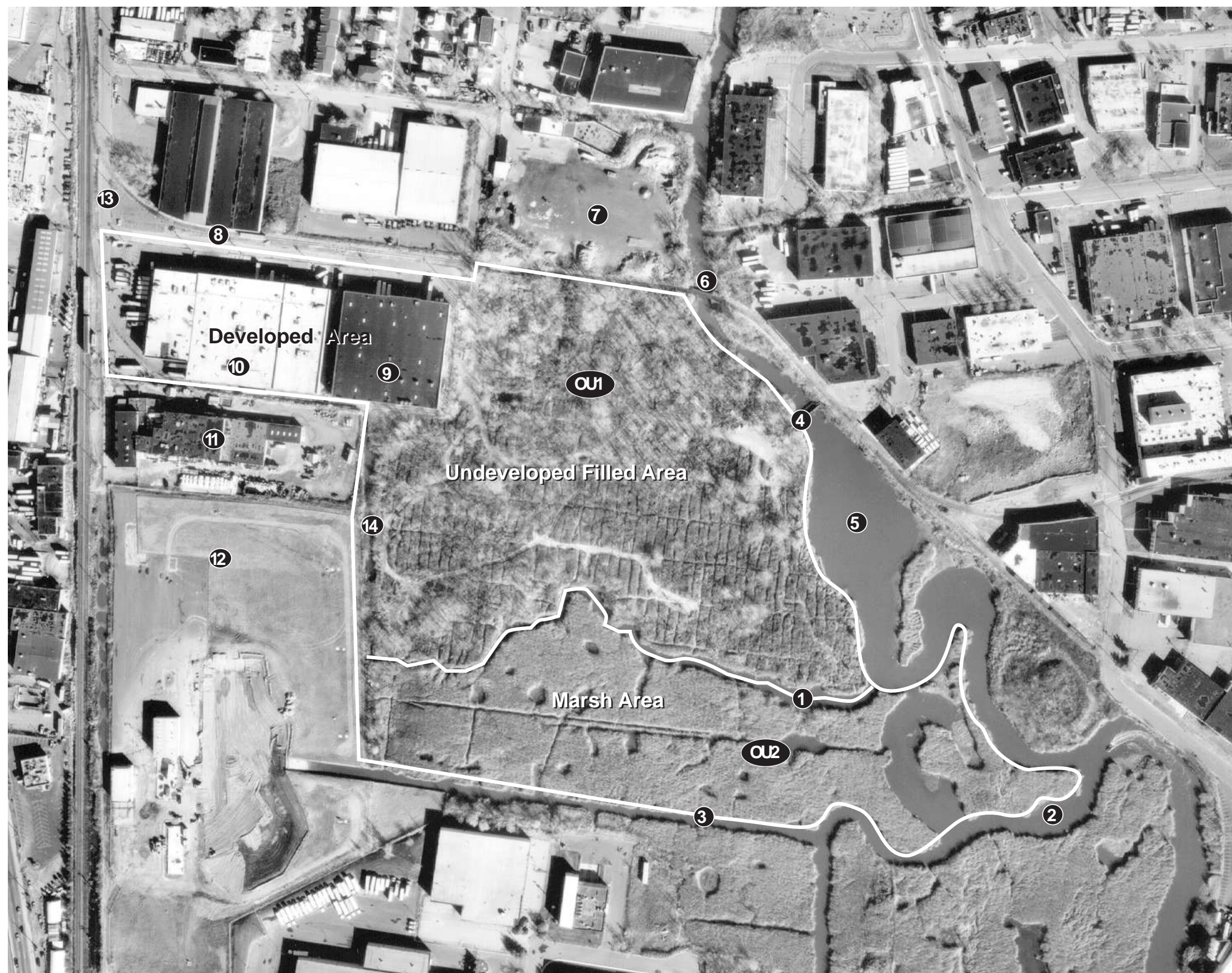
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0 2000 4000 feet

Base map source: USGS Weehawken, NJ-NY quadrangle

Figure 1-1. Site location map.



LEGEND

- ① Diamond Shamrock/Henkel ditch (north)
- ② Nevertouch Creek
- ③ Diamond Shamrock/Henkel ditch (south)
- ④ Tide gate
- ⑤ Berry's Creek
- ⑥ Railroad bridge
- ⑦ Former POTW
- ⑧ Ethel Boulevard
- ⑨ Wolf warehouse
- ⑩ U.S. Life warehouse
- ⑪ Randolph Products
- ⑫ Diamond Shamrock/Henkel Property
- ⑬ Park Place East
- ⑭ West ditch

 Site boundary shown as white line

OU1 Operable Unit 1

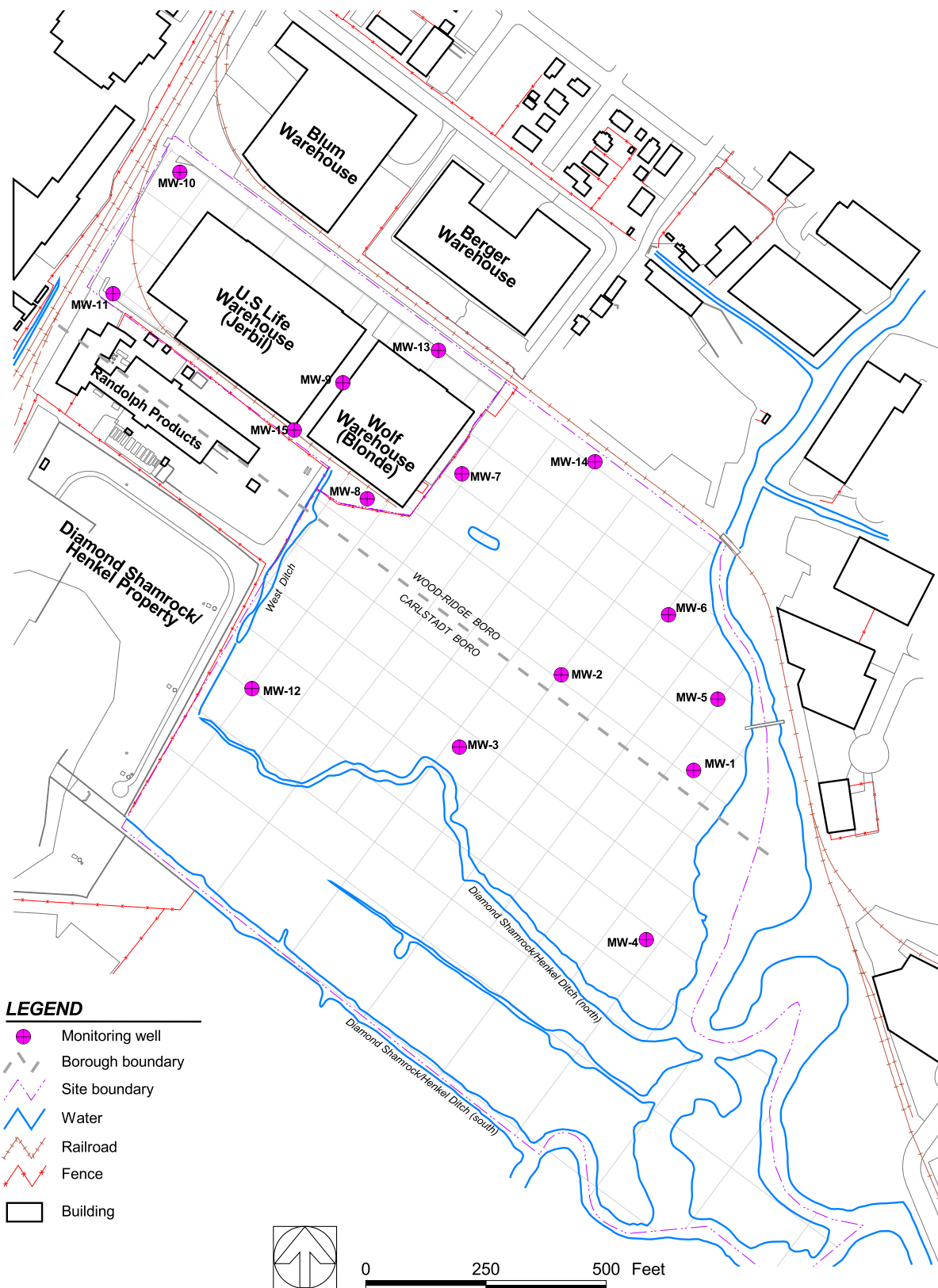
OU2 Operable Unit 2



0 200
feet
approximate scale

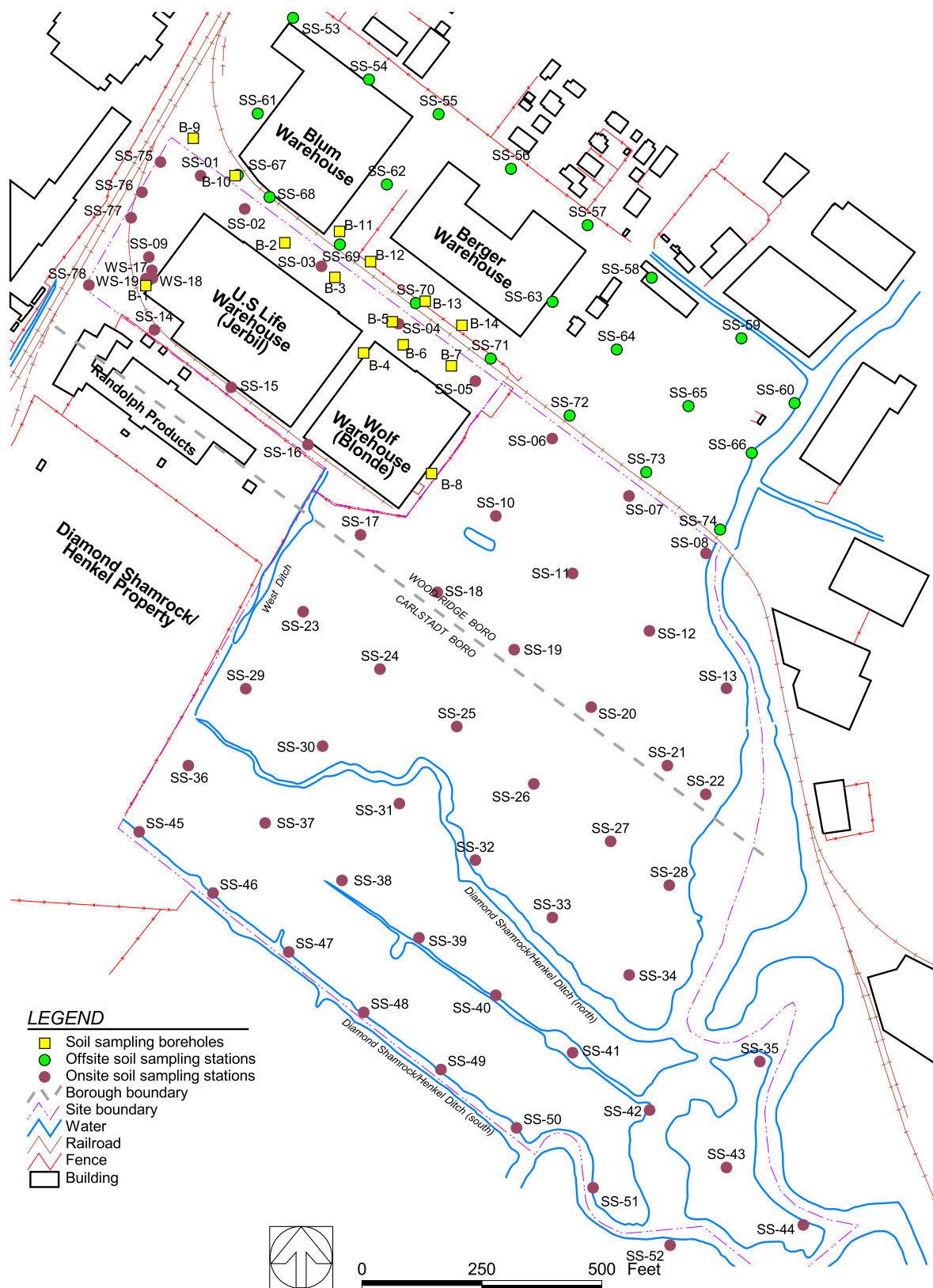
Photograph source: James Stewart, Inc. (November 29, 1997)

Figure 1-2. Site layout map.



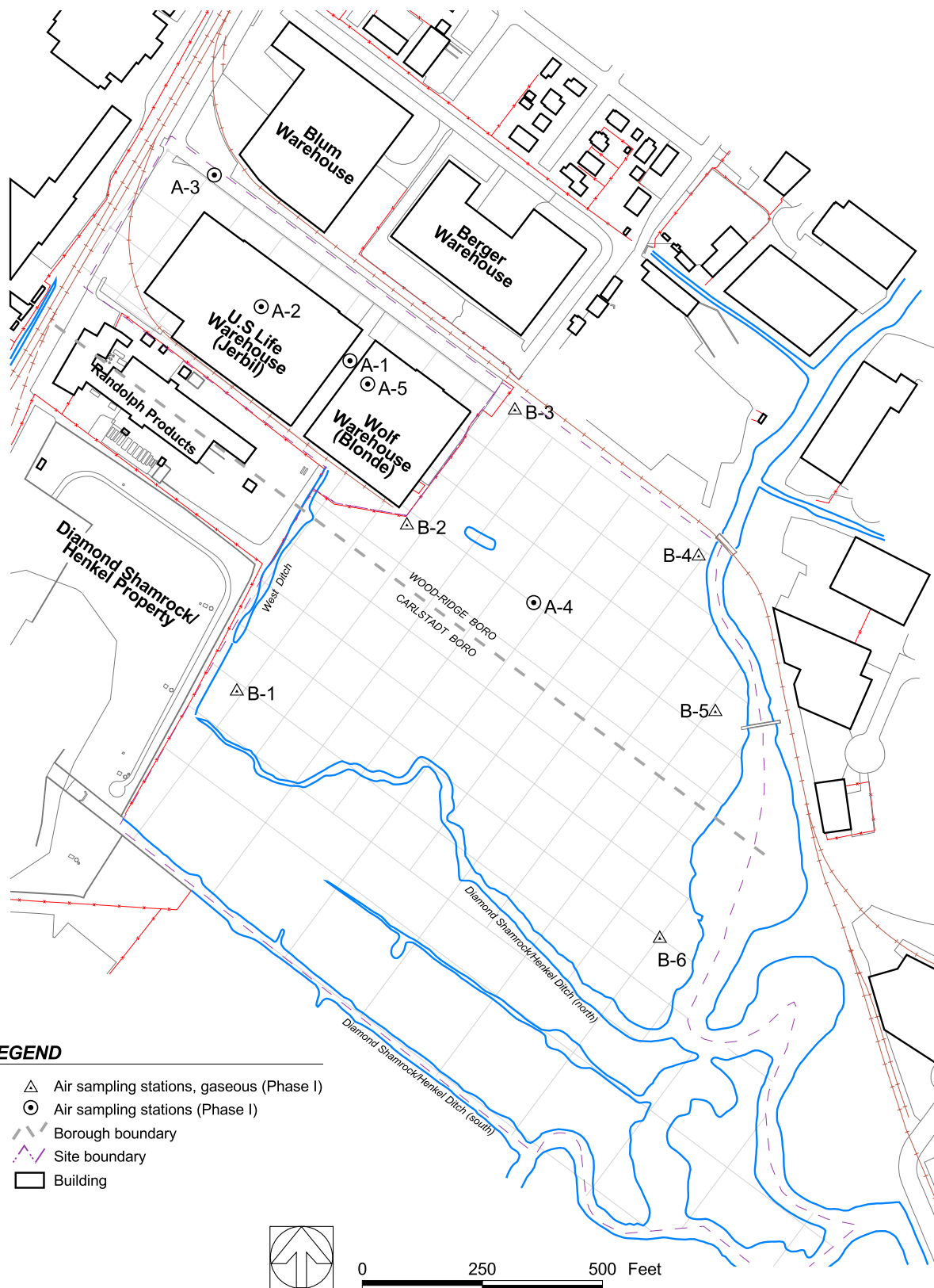
Source map survey by: James Stewart, Inc.

Figure 2-1a. Monitoring well locations.



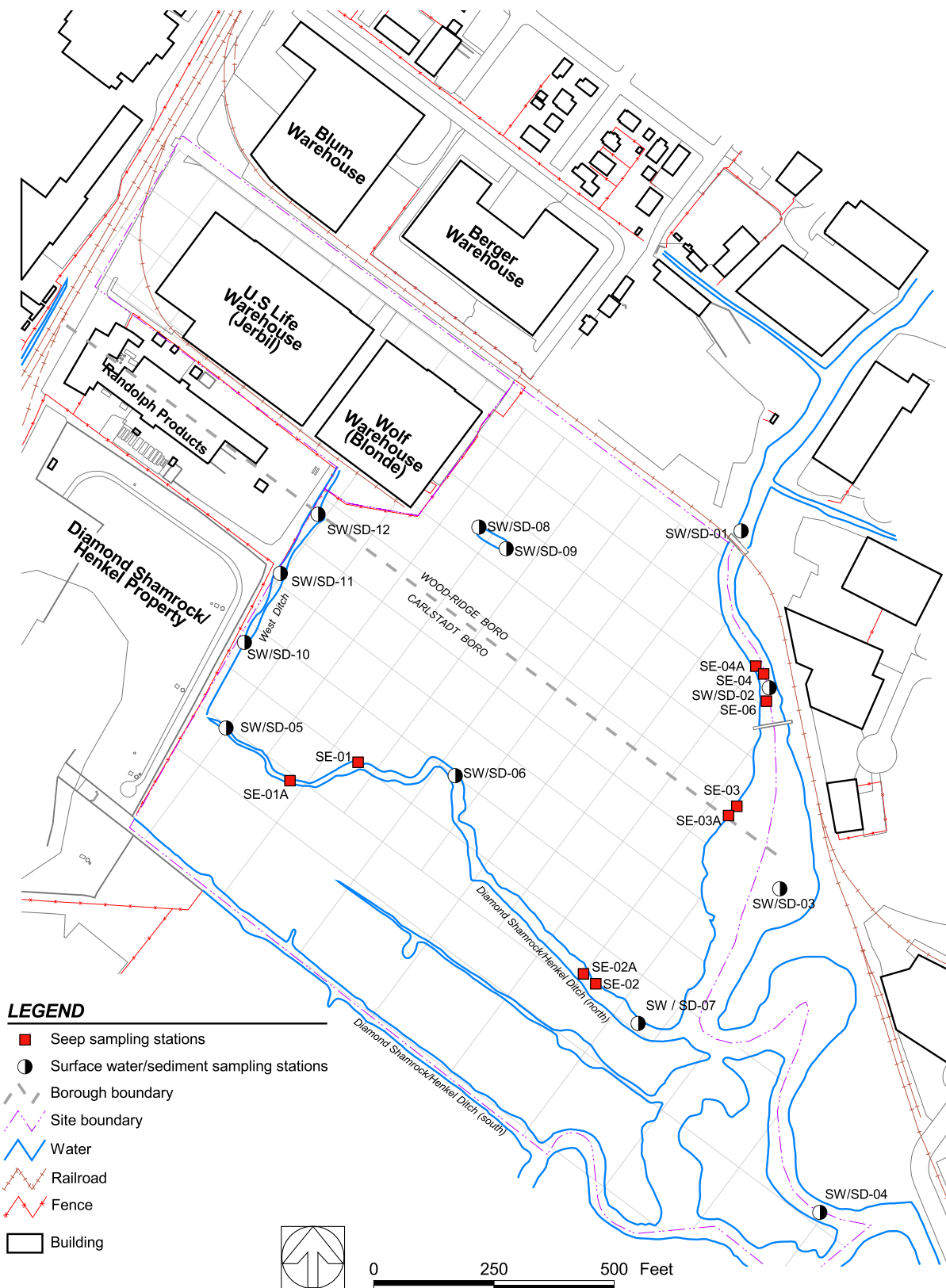
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Figure 2-1b. Onsite and offsite soil sampling stations.



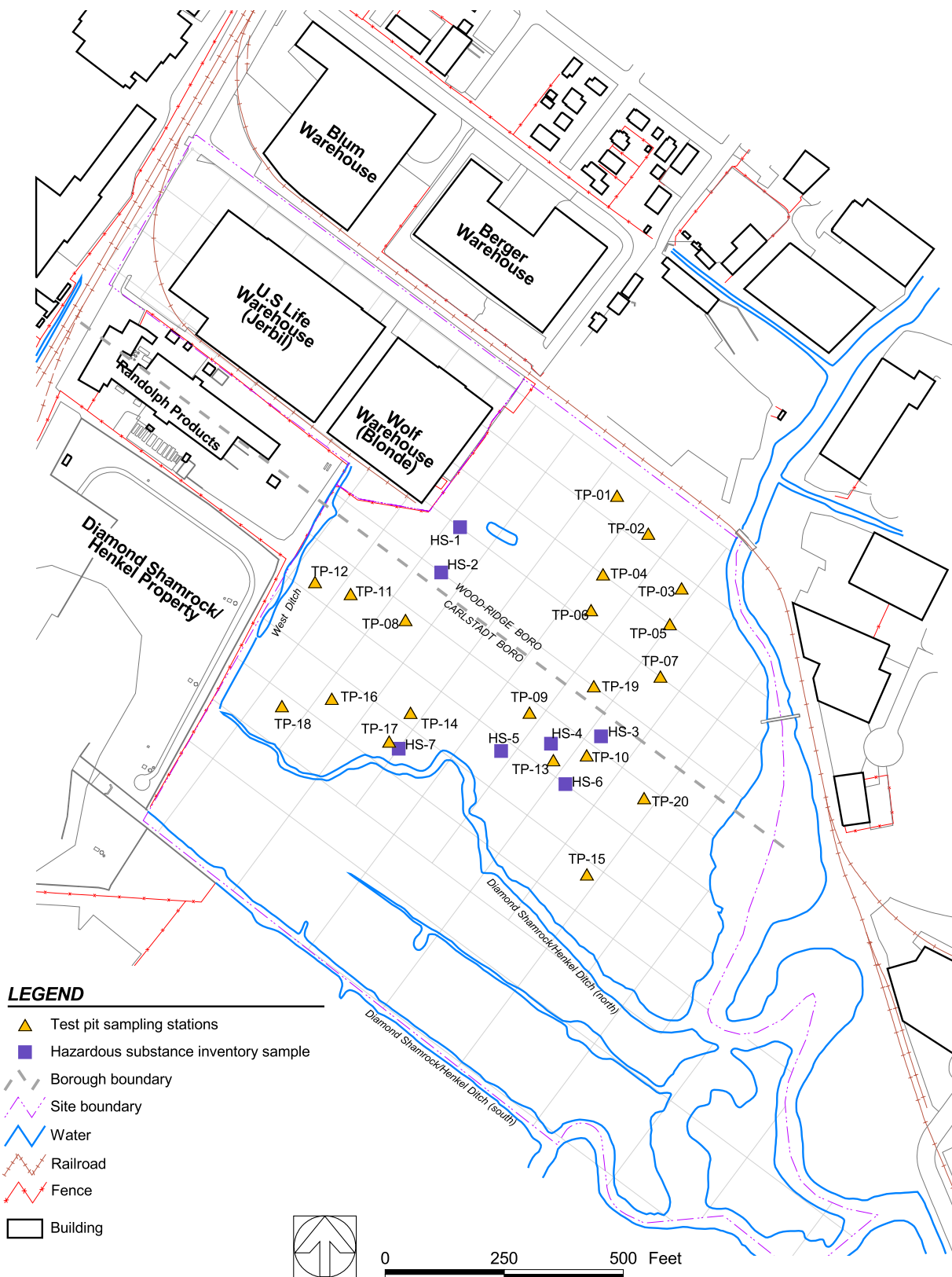
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Figure 2-1c. Air sampling stations.



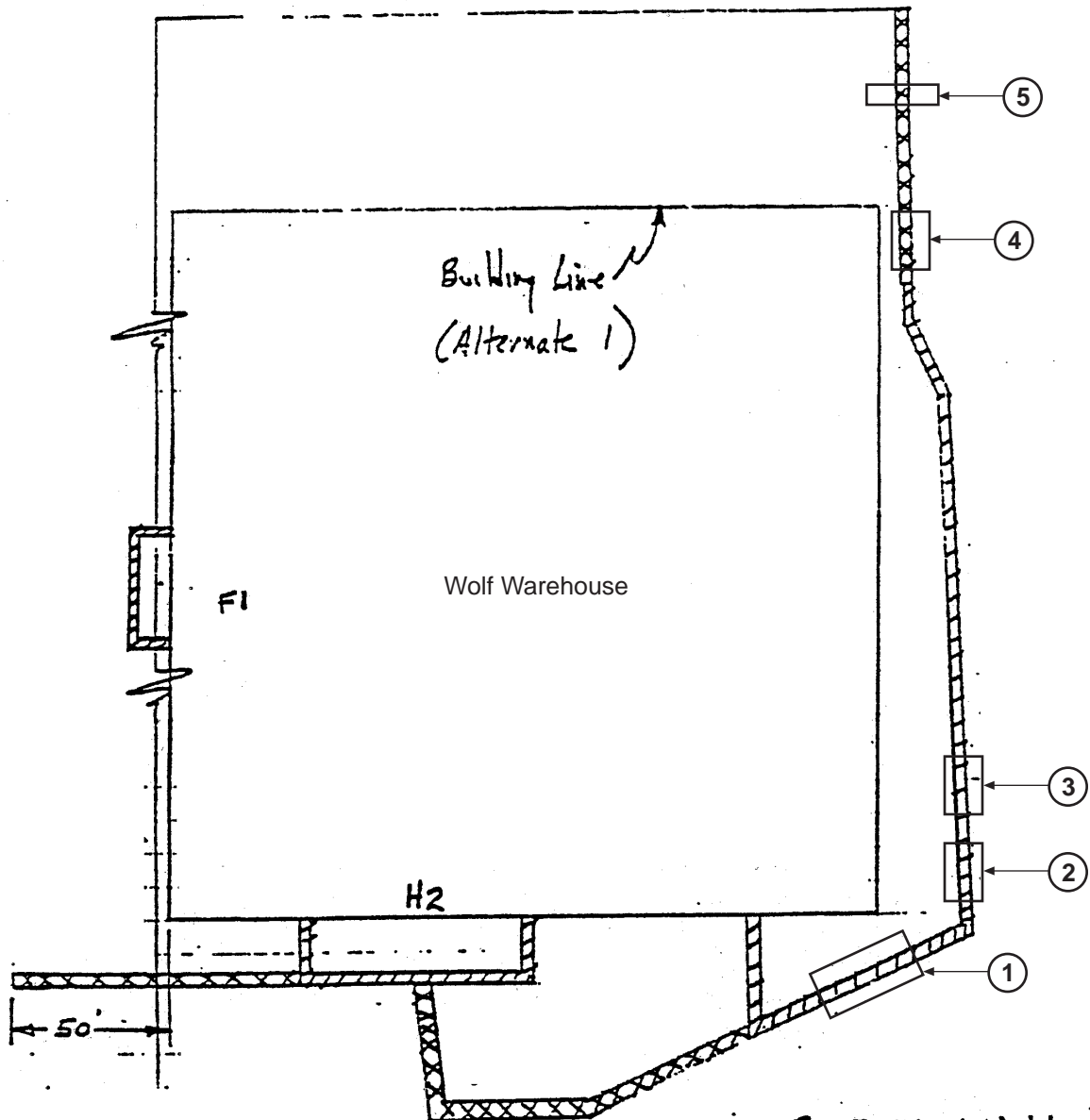
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Figure 2-1d. Surface water, sediment and seep sampling stations.






Source map survey by: James Stewart, Inc.

Figure 2-1e. Test pits and hazardous substance inventory stations.



LEGEND

-  Alternate 2
-  Alternate 3
-  Excavation location

CUTOFF WALL ALTERNATE
Woodbridge, N.J.

Joseph S. Ward Inc
Consulting Engineers
Caldwell N.J.
C7403-3

Jan. 1975

MTH 33813

Source: Base map modified from
Joseph S. Ward, Inc., 1975

Figure 2-2. Cut-off wall excavation locations.

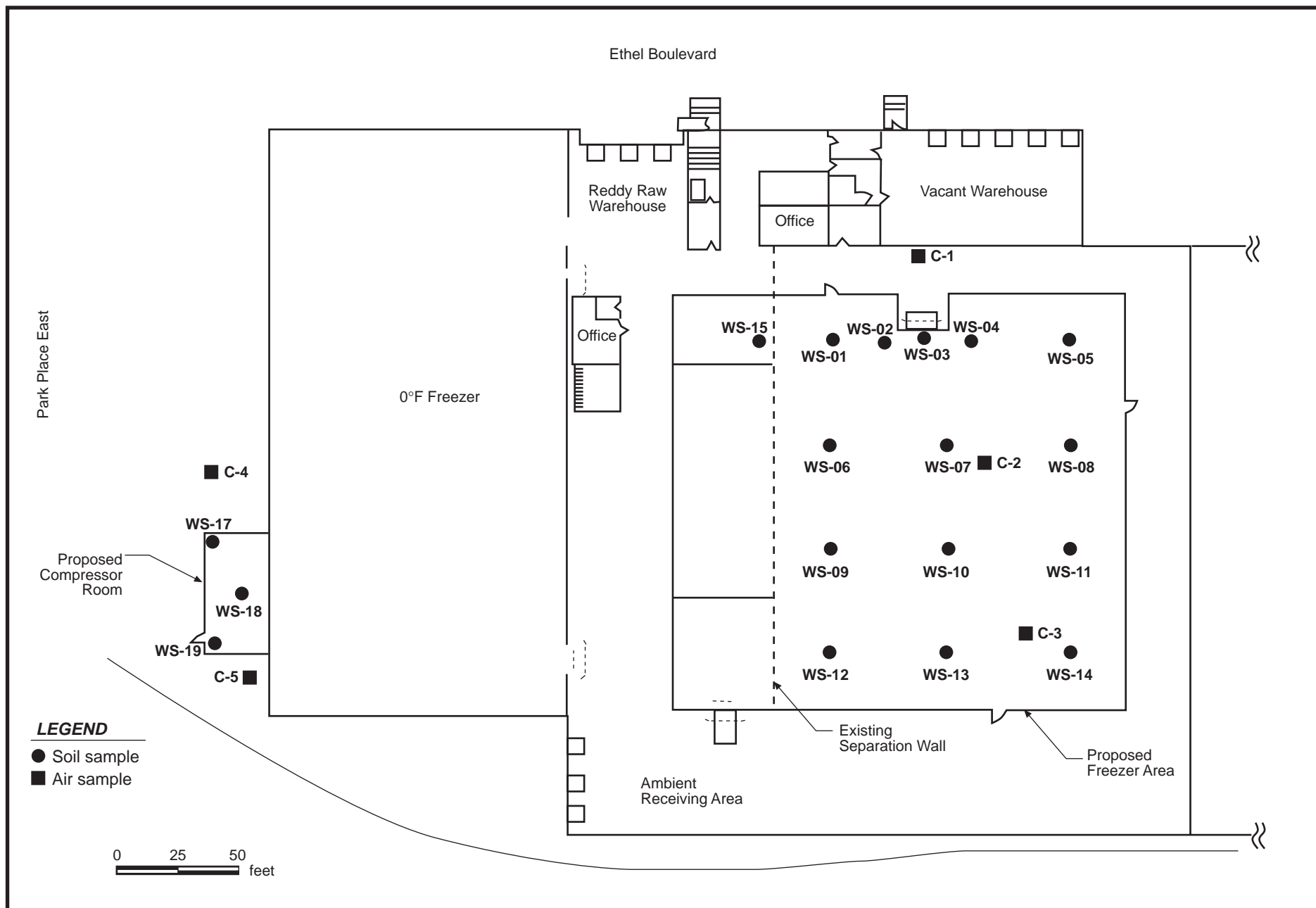


Figure 2-3. U.S. Life Warehouse (Jerbil) evaluation soil and air sample locations

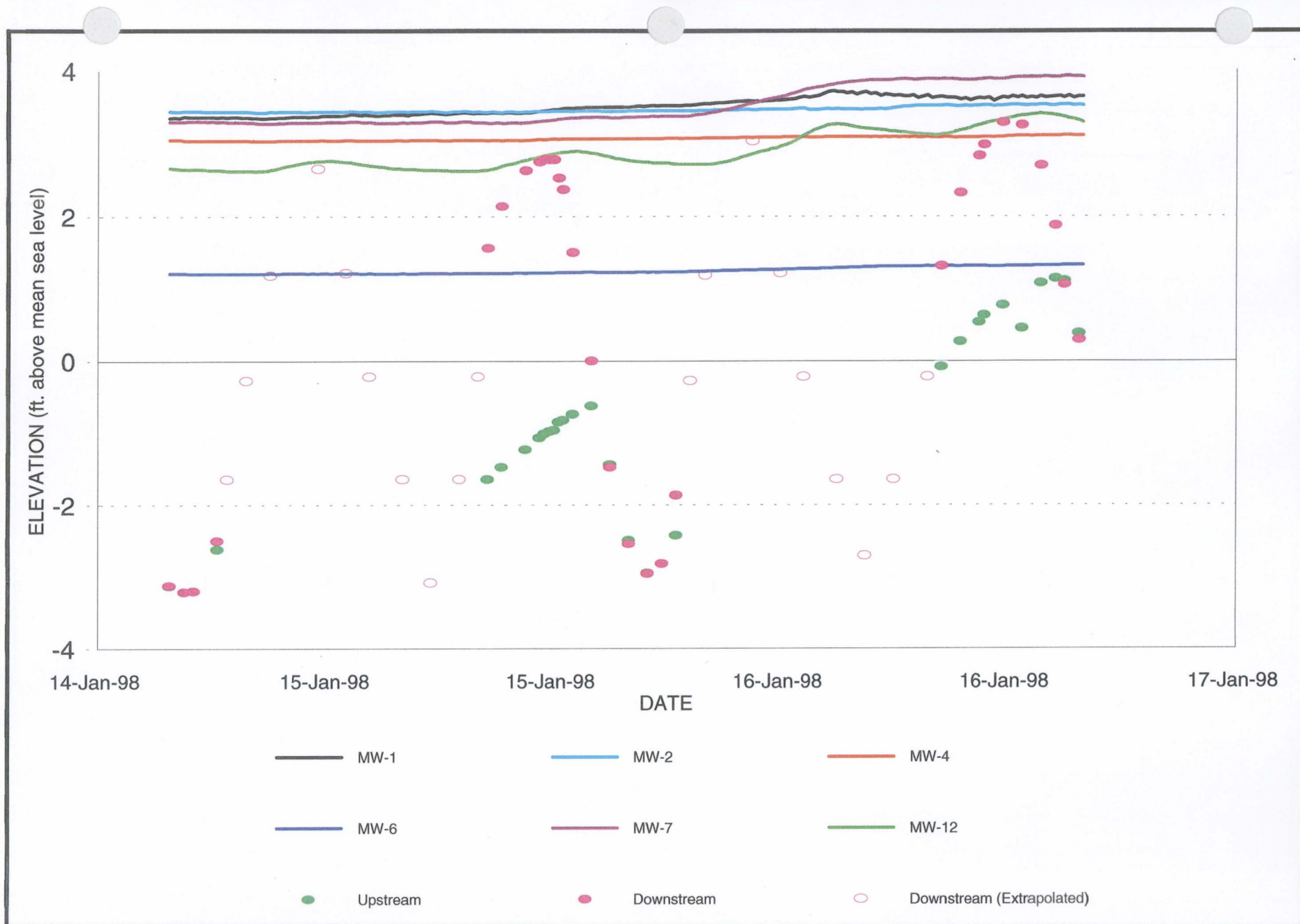


Figure 3-1. Tidal study hydrographs.

LEGEND

- Areas of 500-year flood
- Areas of 100-year flood
- Approximate site boundary

Source: FEMA NFIP, Q3 Flood data, disc 18

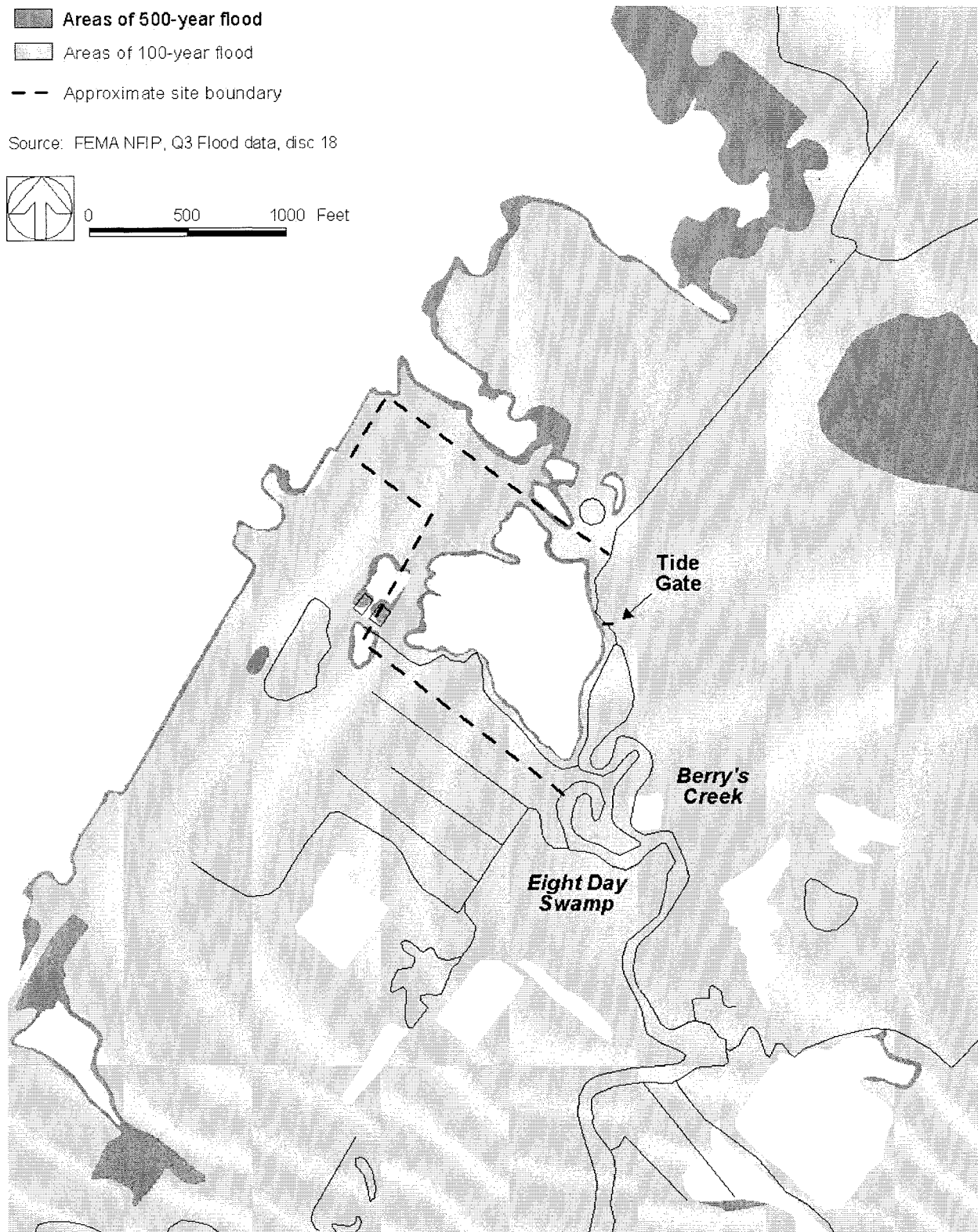


Figure 3-2. 100-year and 500-year floodplain map

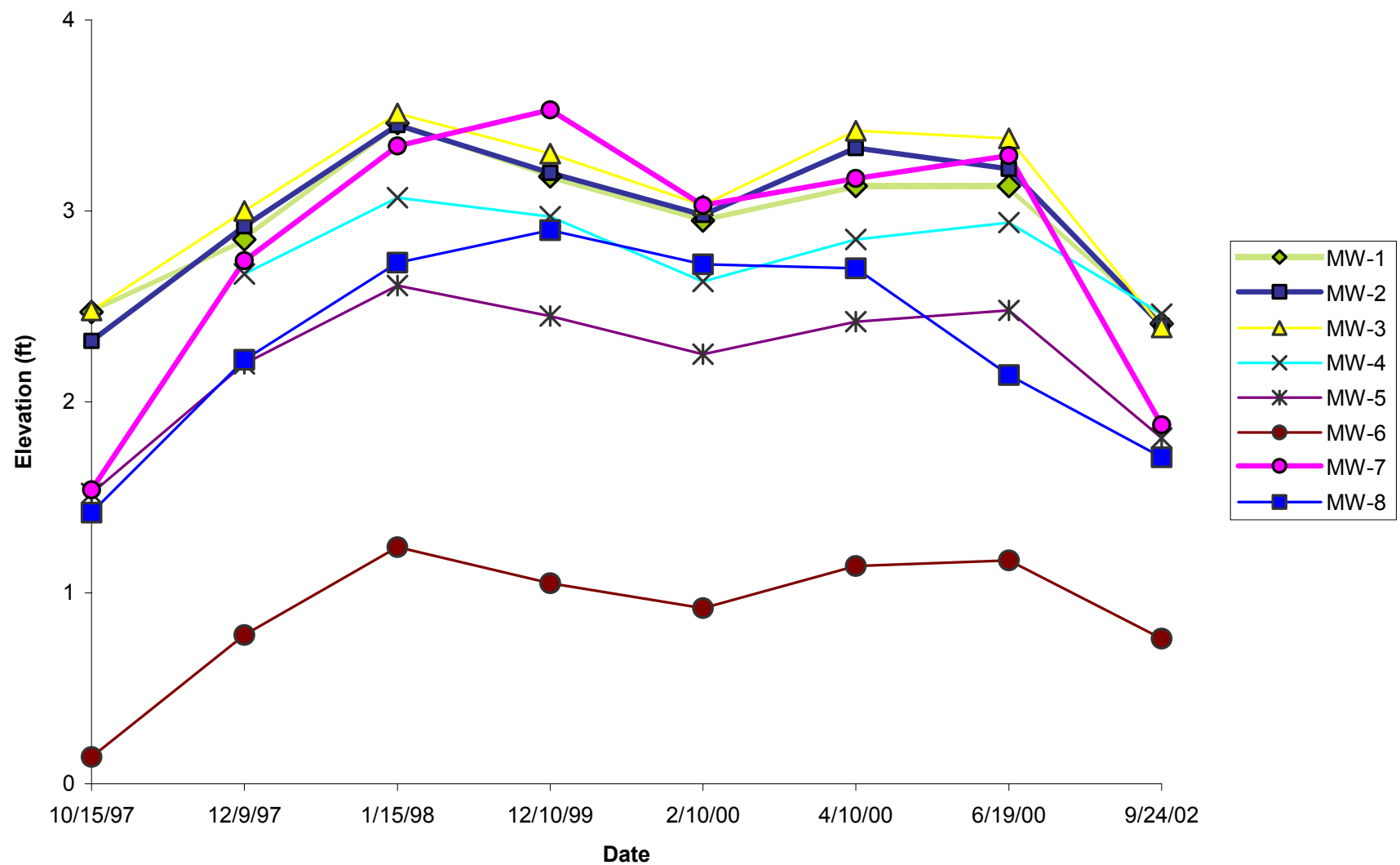


Figure 3-3a. Groundwater surface elevation measurements, time series for each well (MW-1 through MW-8).

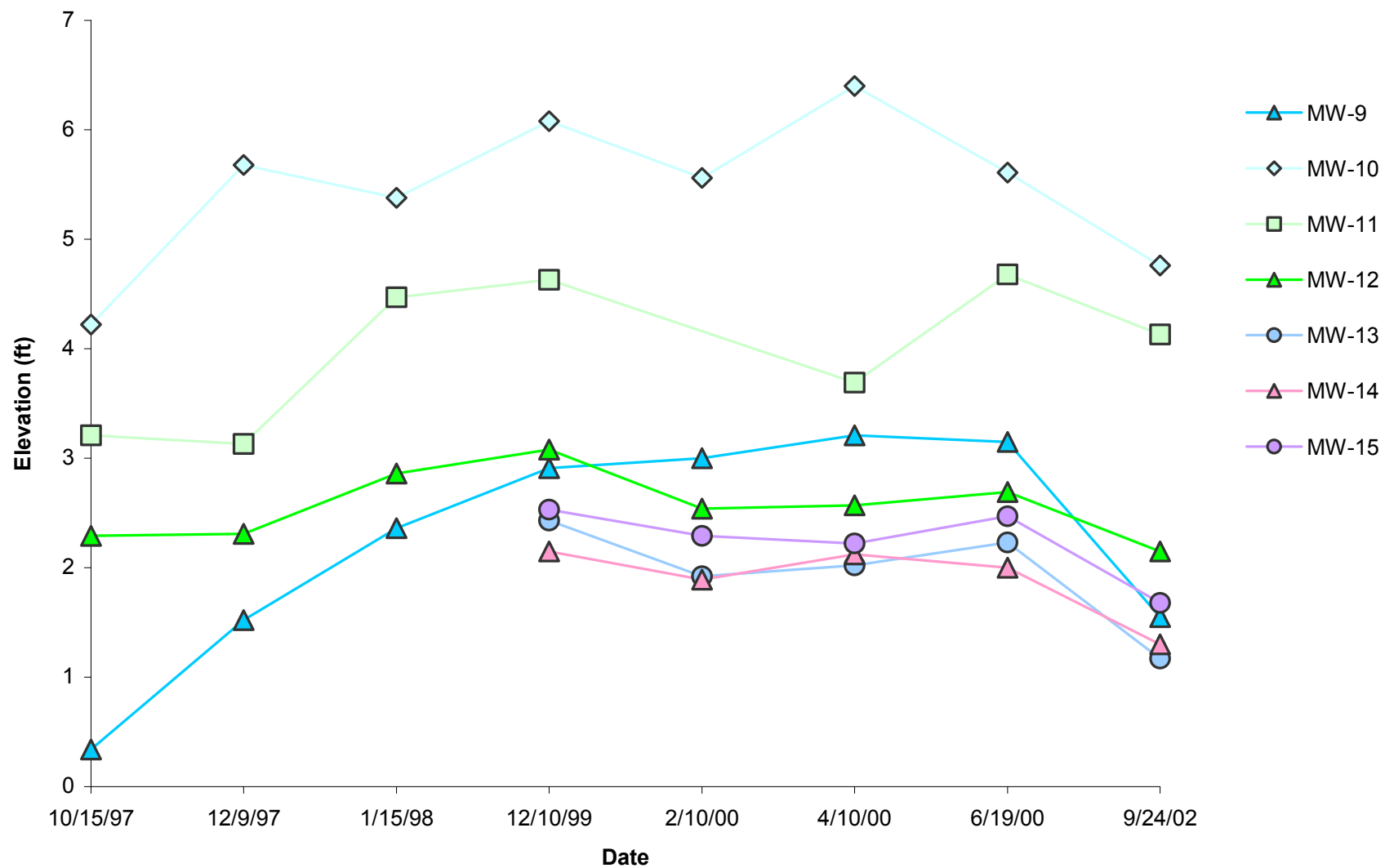


Figure 3-3b. Groundwater surface elevation measurements, time series for each well (MW-9 through MW-15).

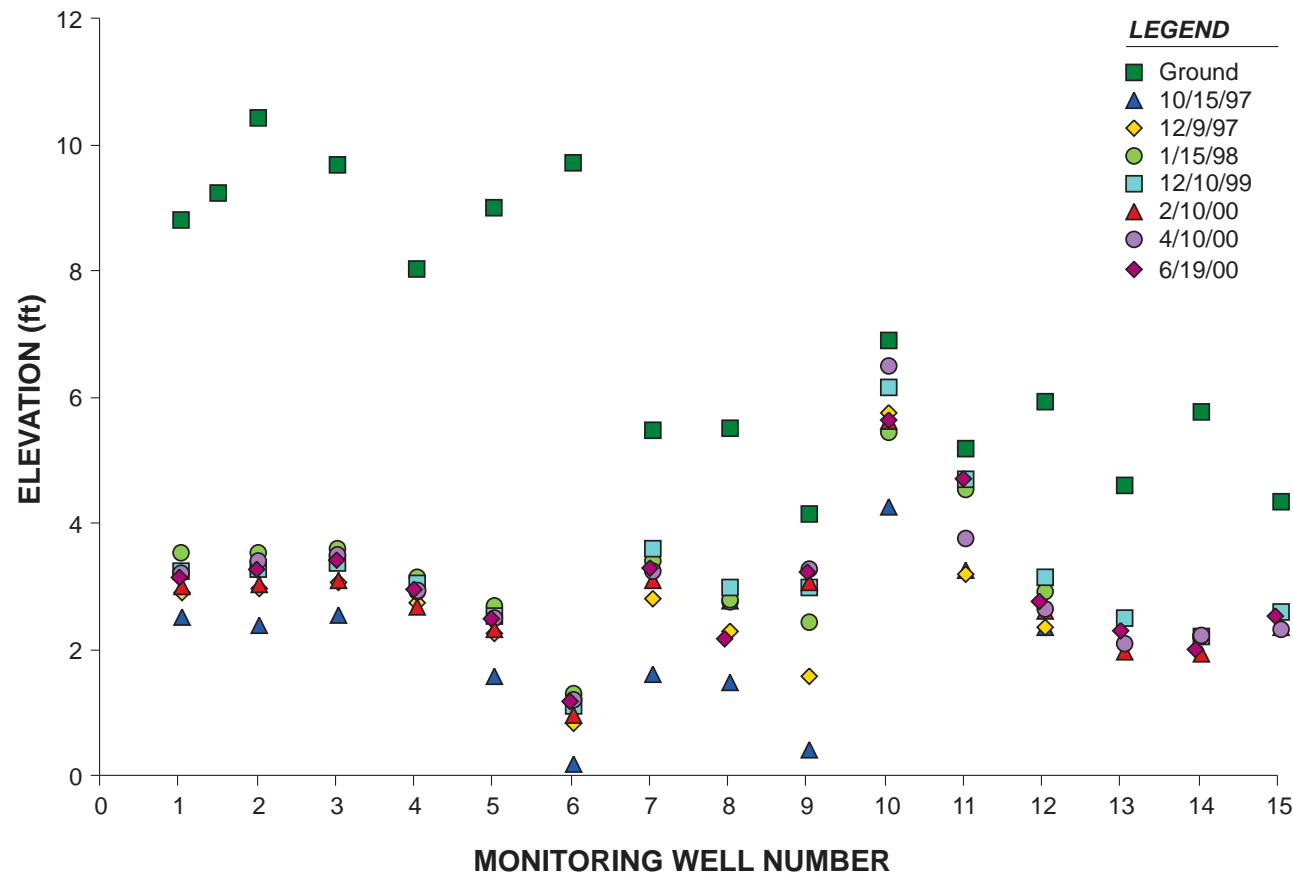
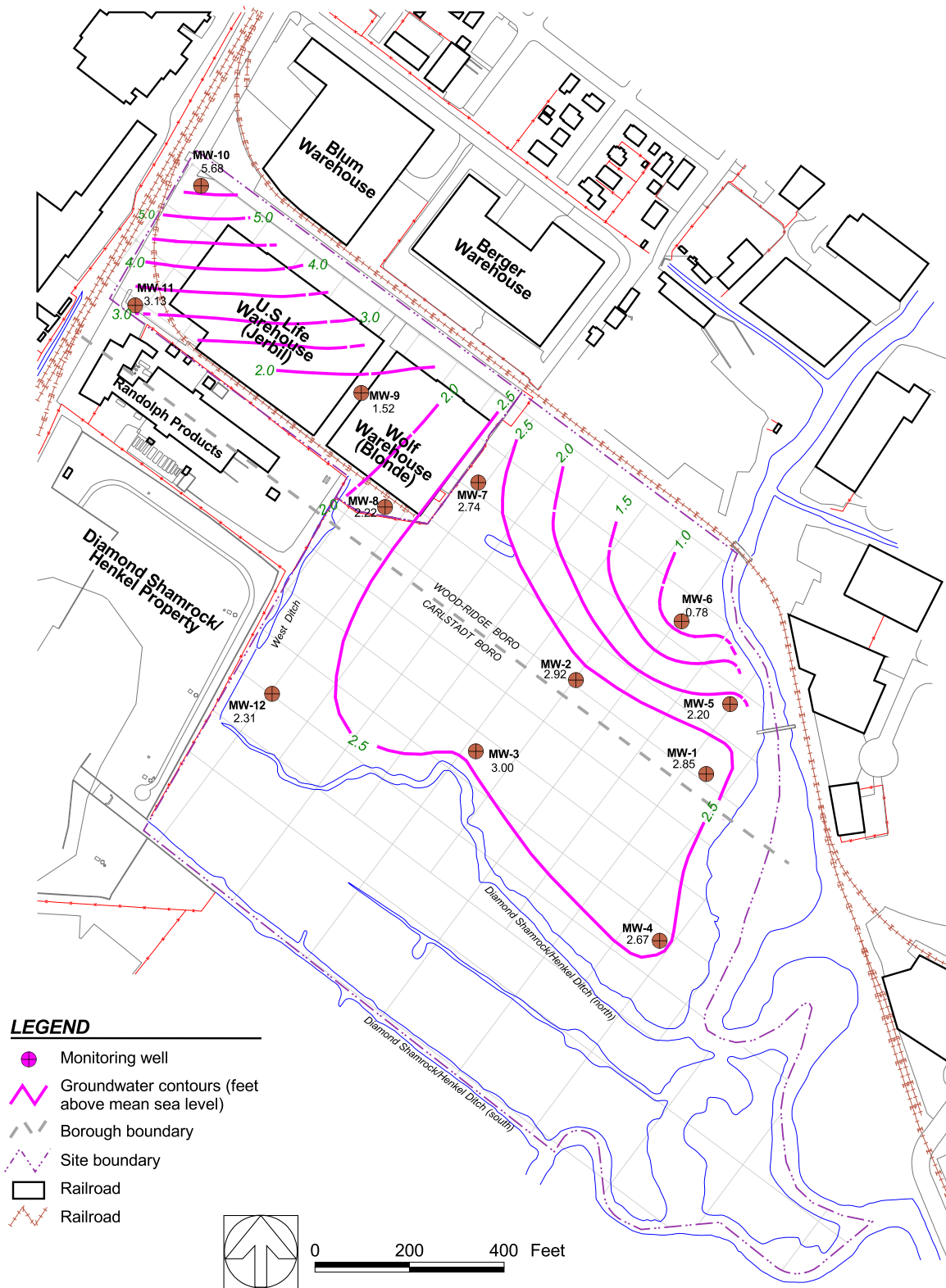
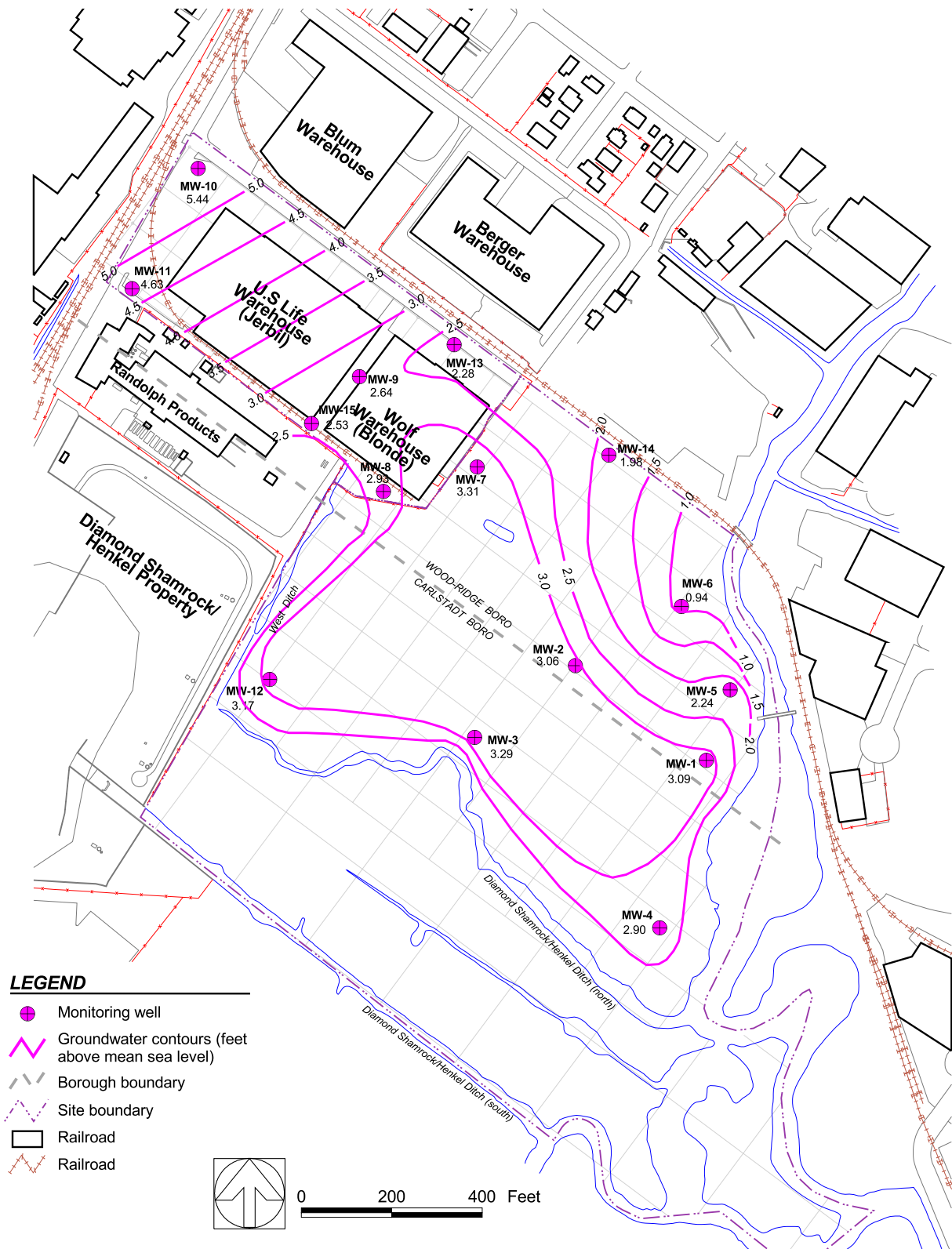


Figure 3-3c. Groundwater surface elevation measurements, variations at each well



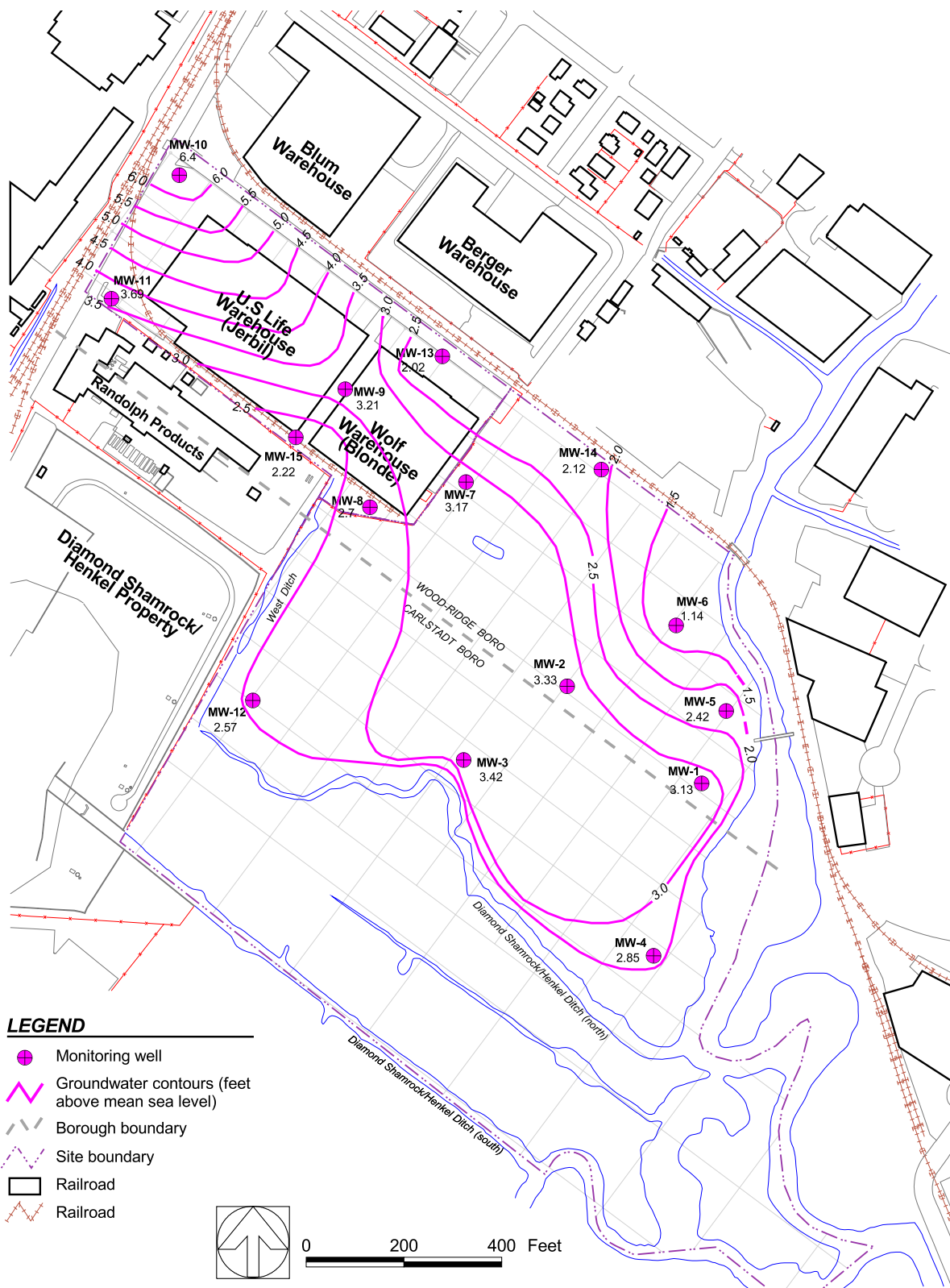
Source map survey by: James M. Stewart, Inc.

Figure 3-4a. Groundwater elevations December 9, 1997.



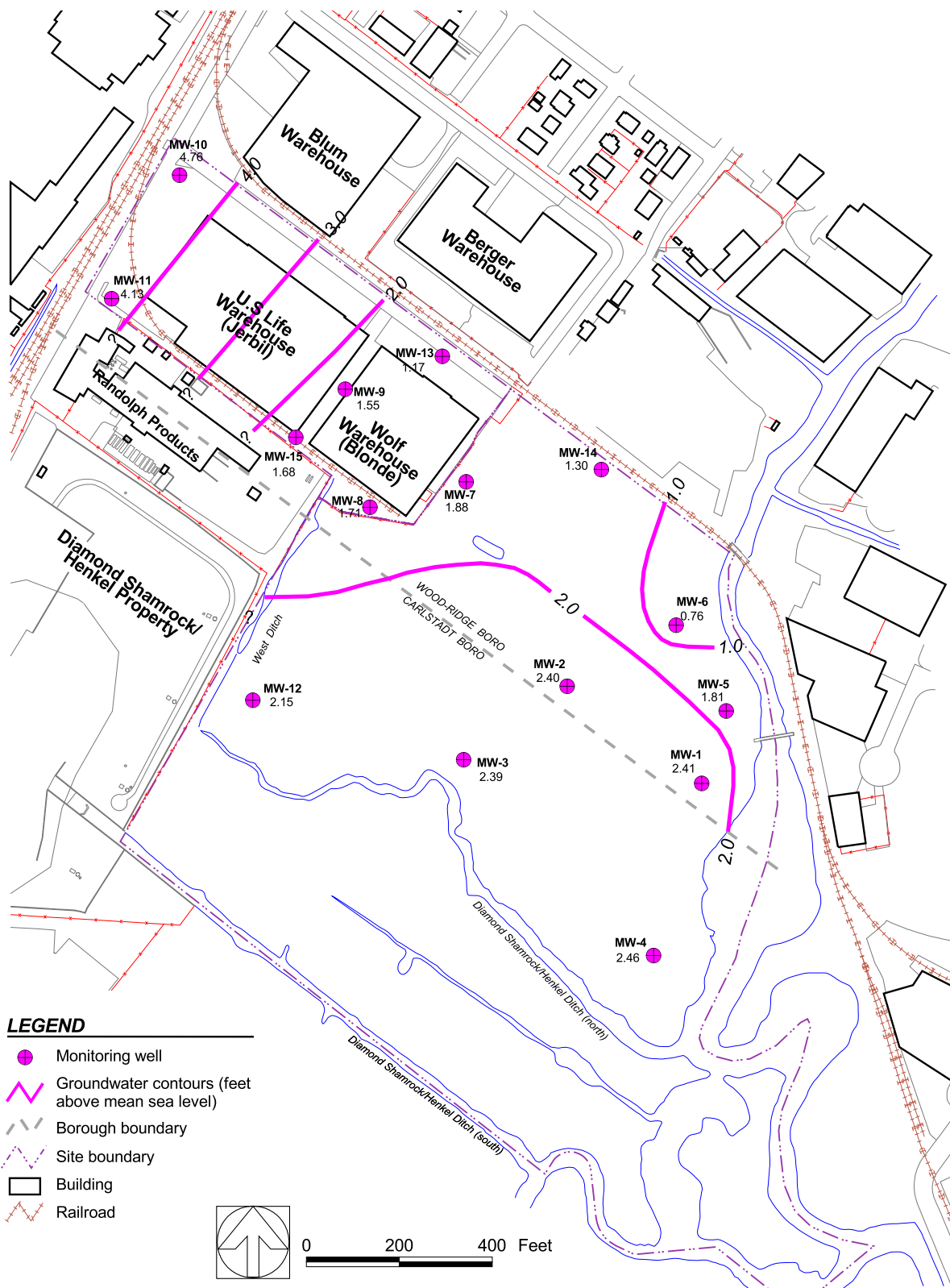
Source map survey by: James M. Stewart, Inc.

Figure 3-4b. Groundwater elevations December 10, 1999.



Source map survey by: James M. Stewart, Inc.

Figure 3-4c. Groundwater elevations April 10, 2000.



Source map survey by: James M. Stewart, Inc.

Figure 3-4d. Groundwater elevations September 24, 2002.

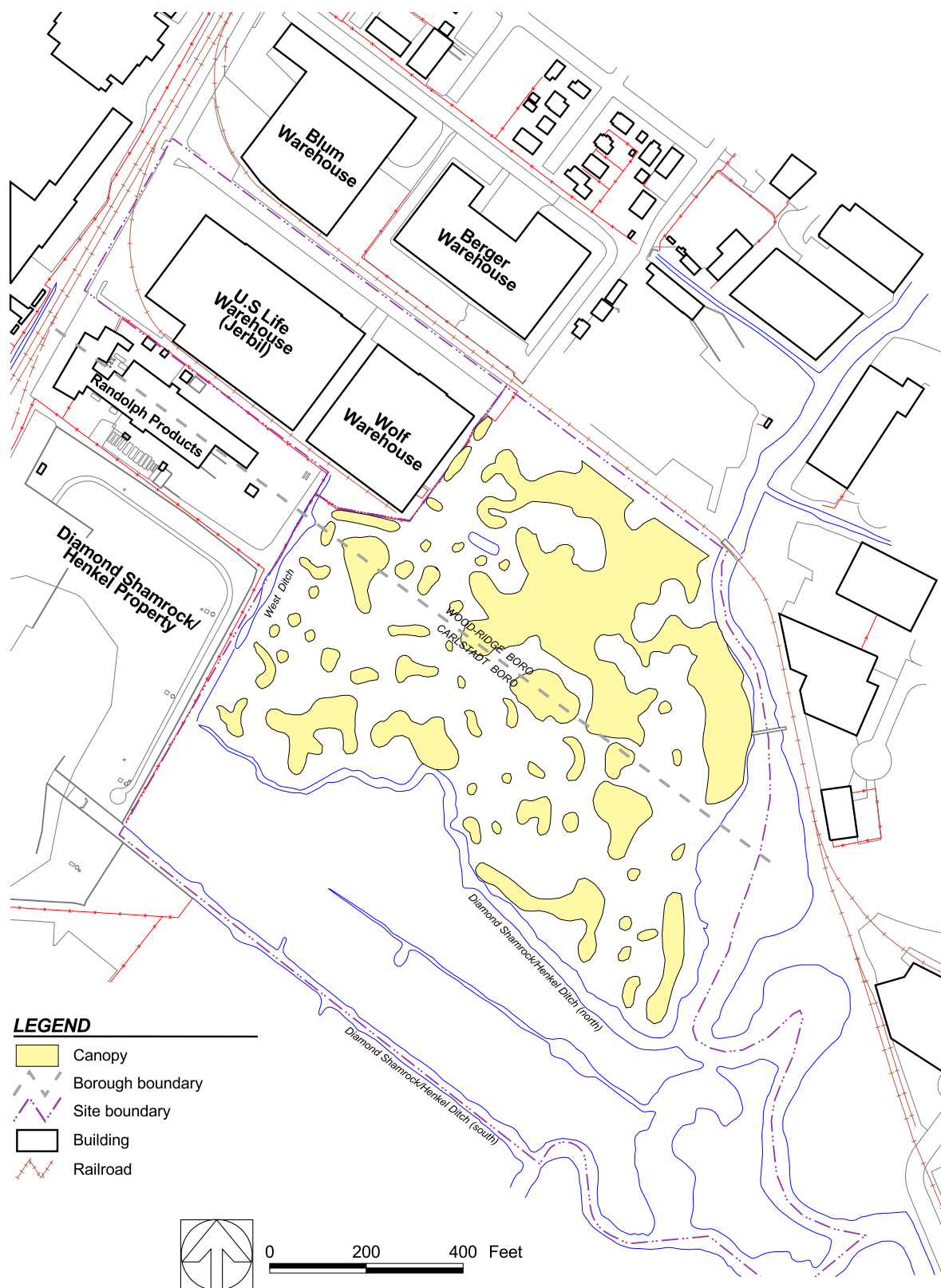


Figure 3-5. Approximate distribution of canopy species at the Ventron/Velsicol site, May 1998.

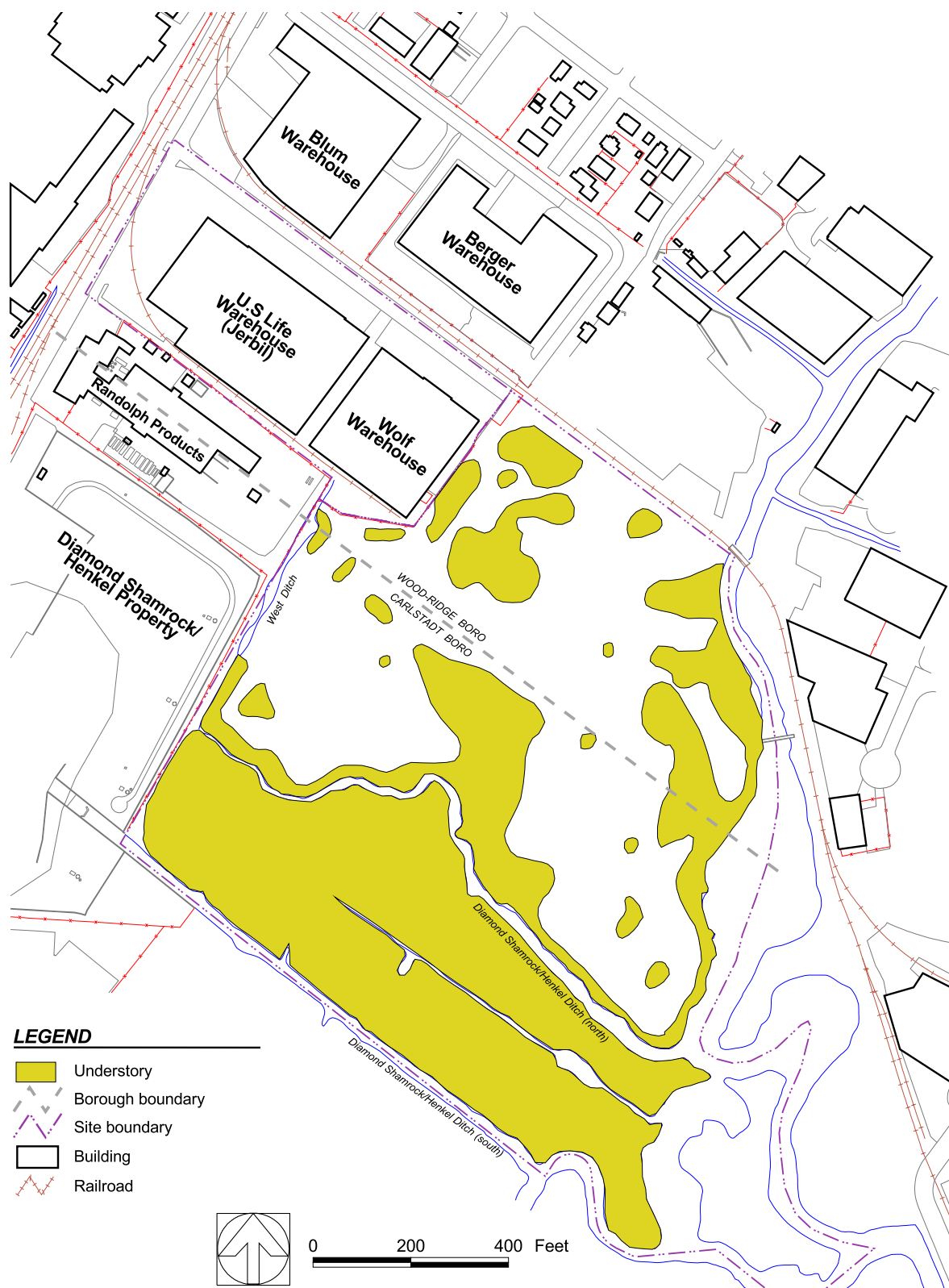


Figure 3-6. Approximate distribution of understory species at the Ventron/Velsicol site, May 1998.

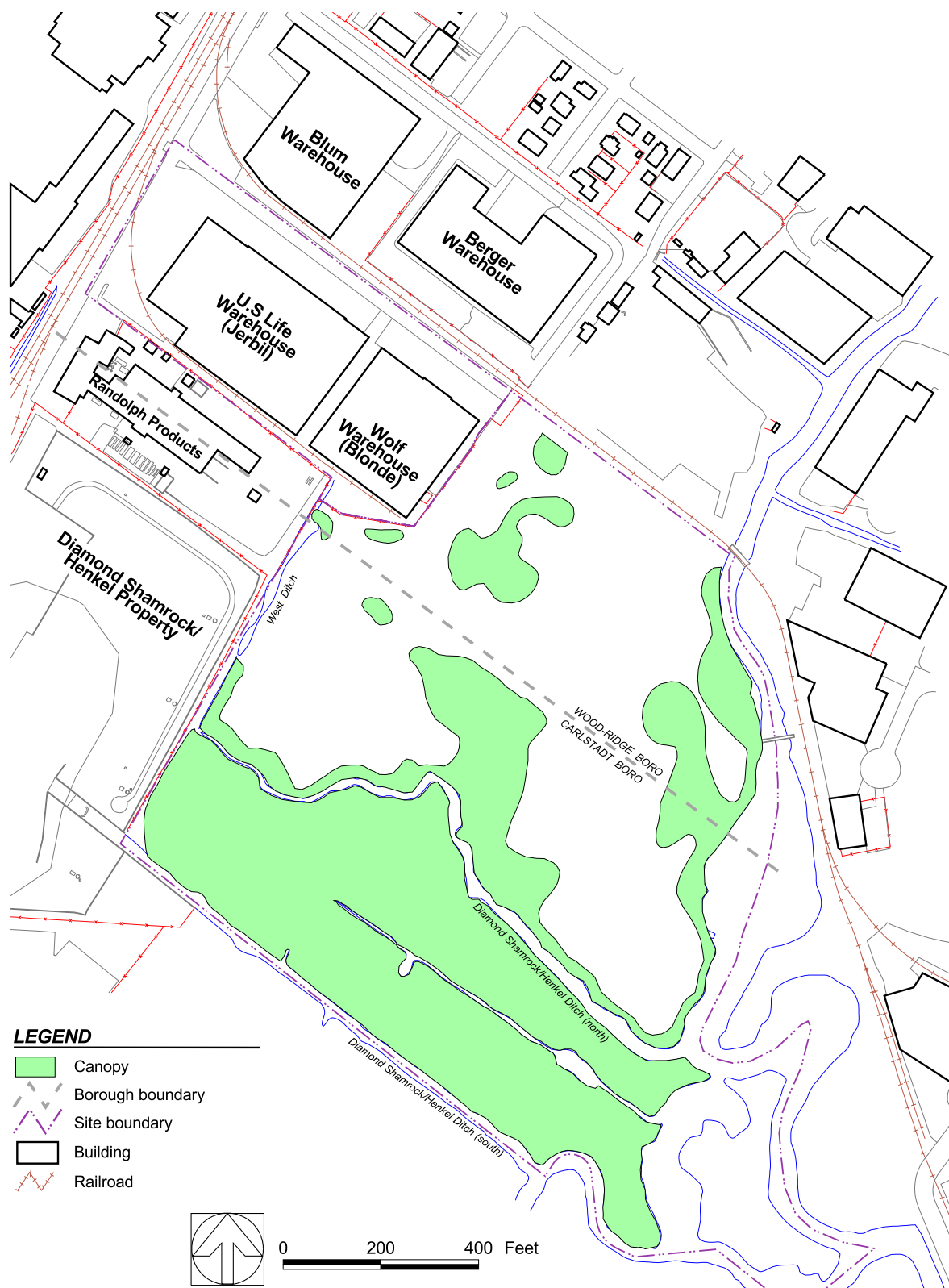
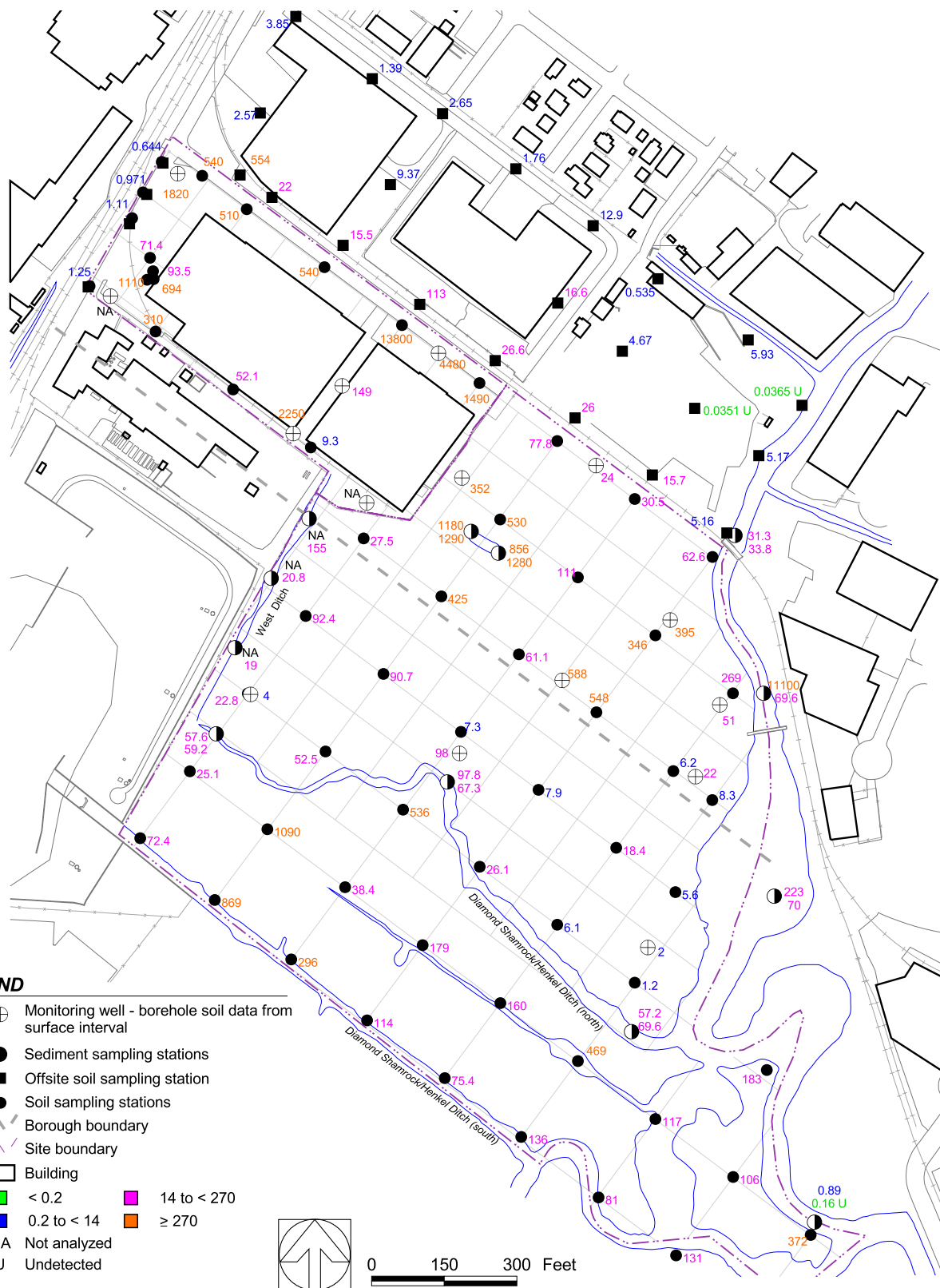
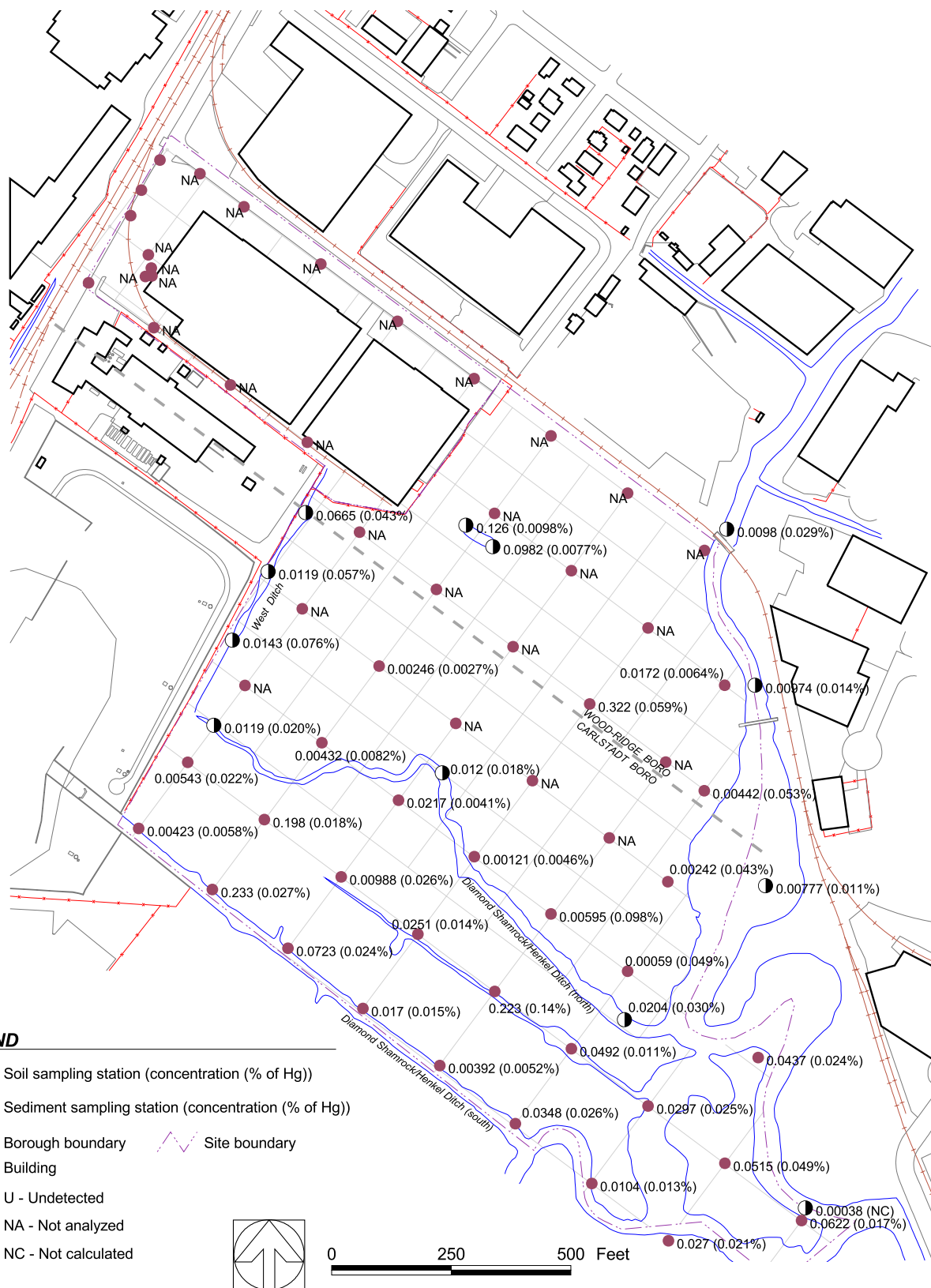


Figure 3-7. Approximate distribution of *Phragmites australis* at the Ventron/Velsicol site, May 1998.



Source map survey by: James Stewart, Inc.

Figure 4-1. Mercury concentrations (mg/kg) in surface soils and sediments (color coding based on screening criteria values).



Source map survey by: James Stewart, Inc.

Figure 4-2 . Methylmercury concentrations (mg/kg and as percentage of total mercury) in surface soils and sediments.

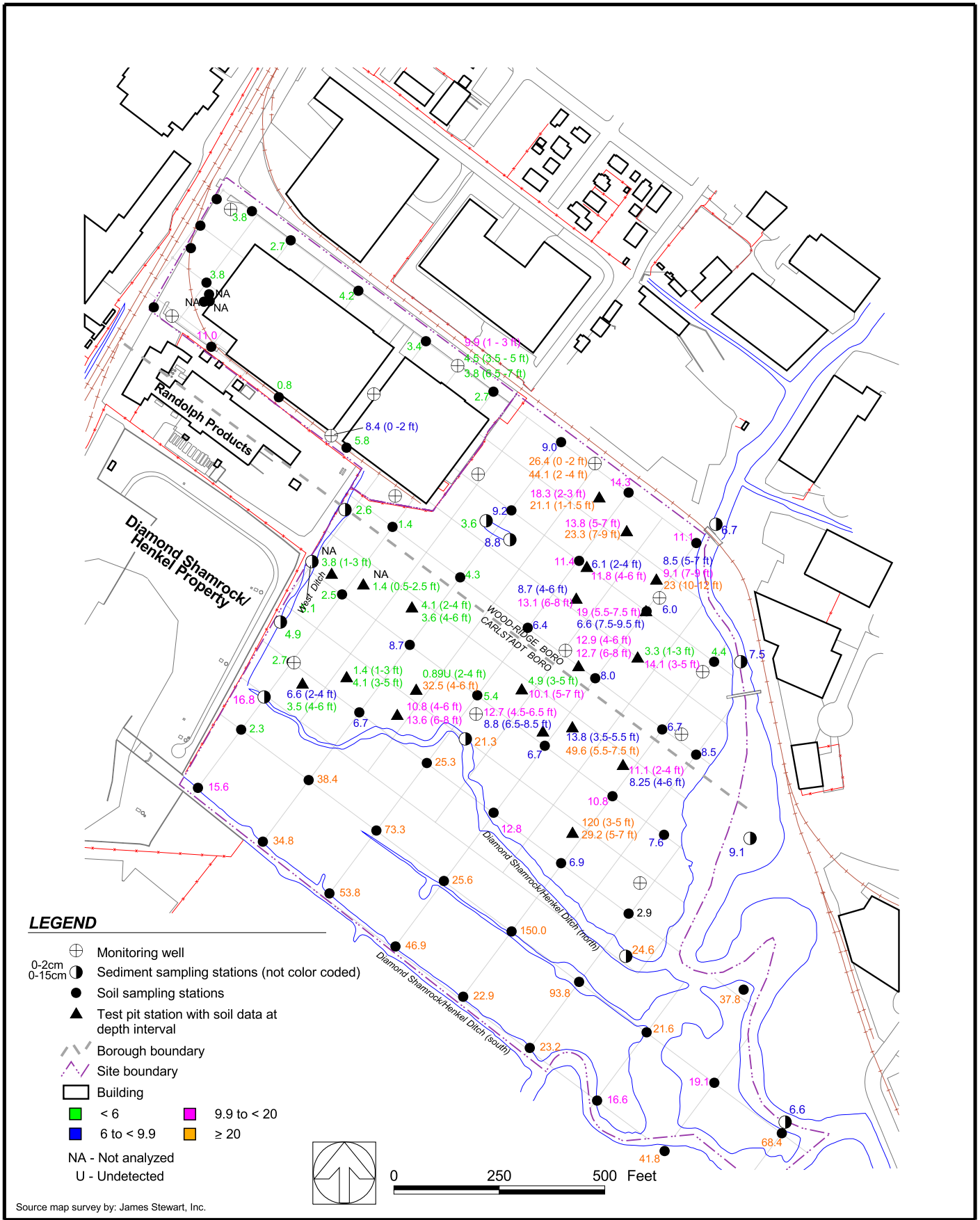


Figure 4-3. Arsenic concentrations (mg/kg) in surface and subsurface soils and sediments (color coding based on screening criteria values).

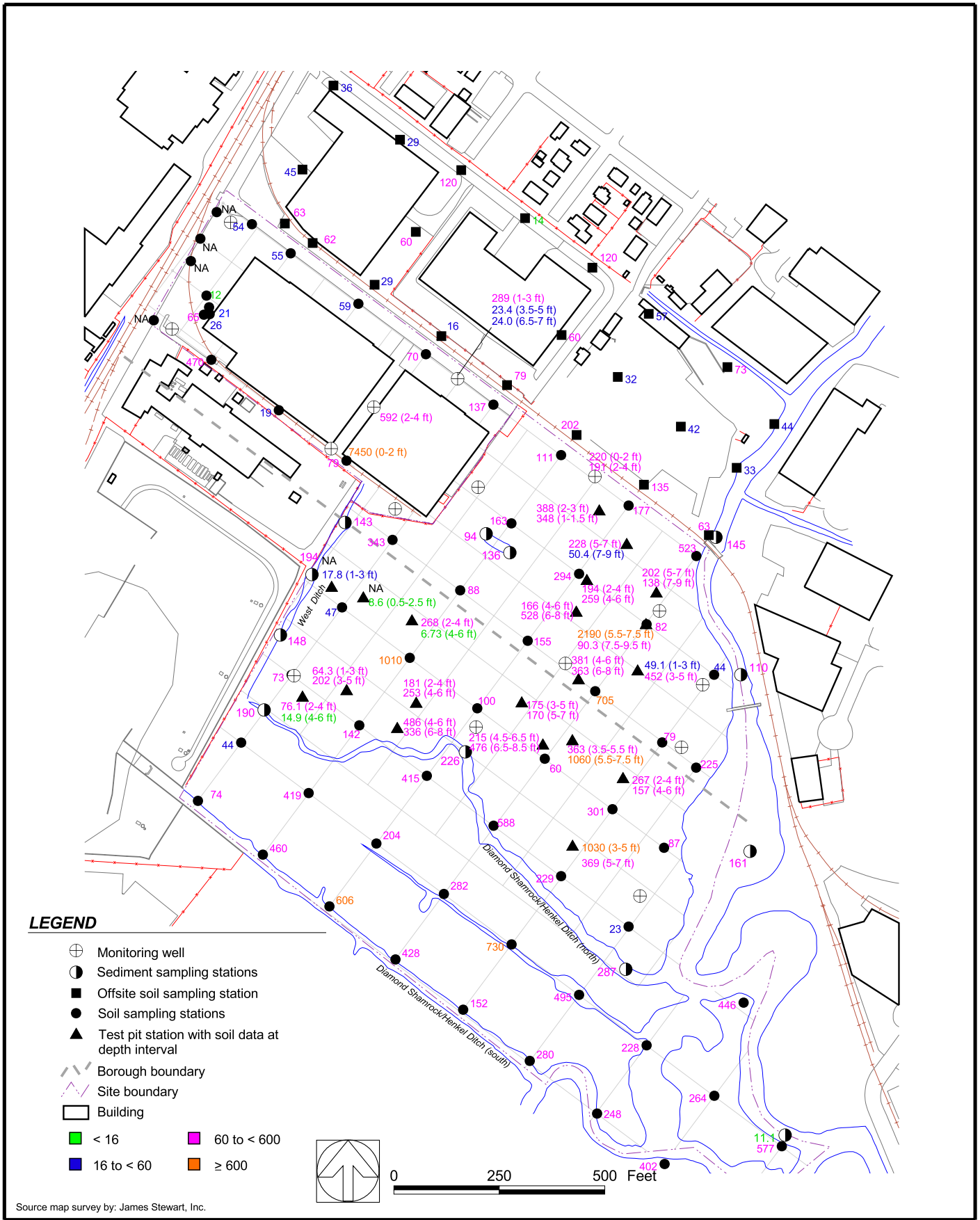


Figure 4-4. Copper concentrations (mg/kg) in surface and subsurface soils and sediments (color coding based on screening criteria values).

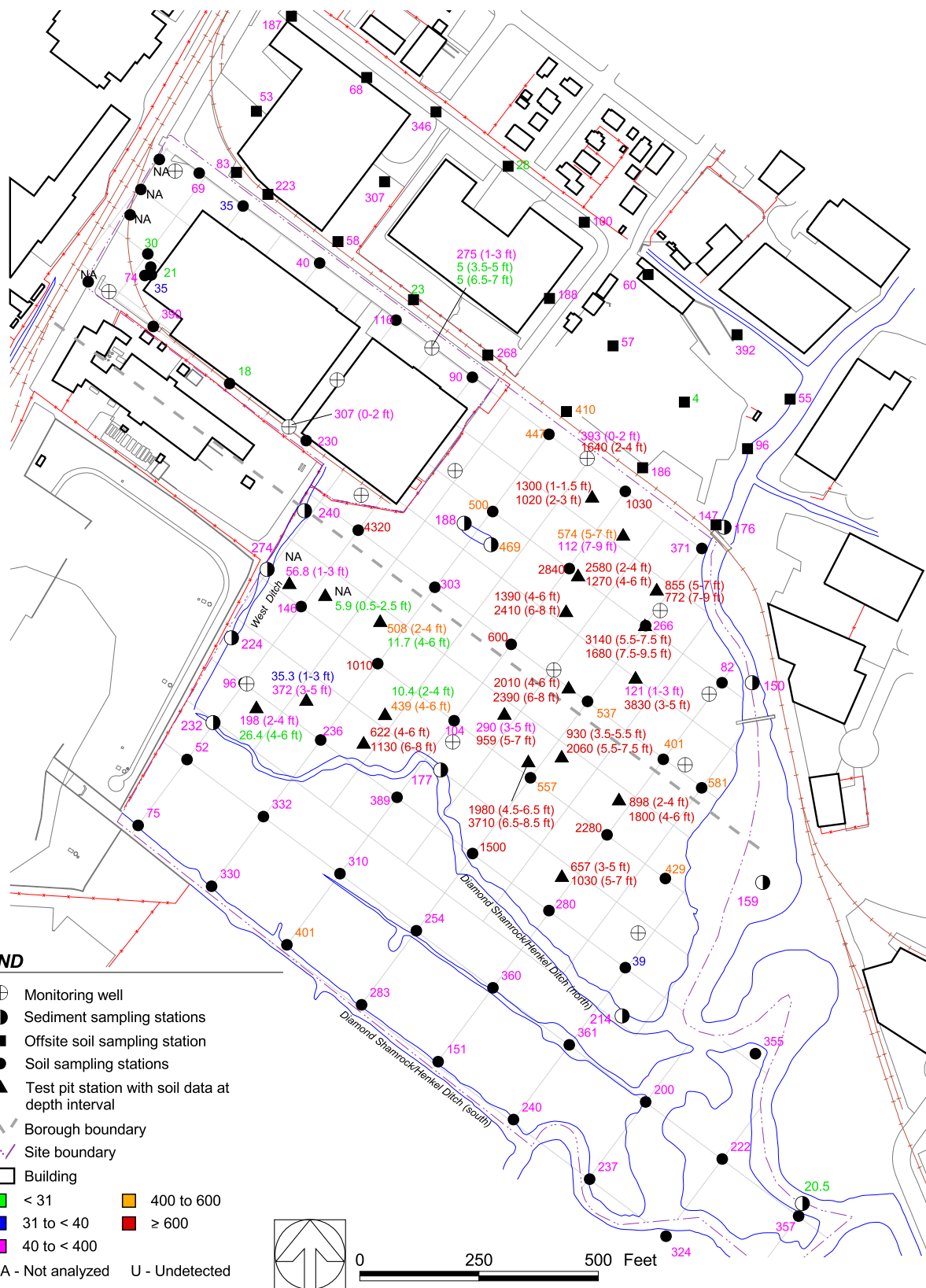


Figure 4-5. Lead concentrations (mg/kg) in surface and subsurface soils and sediments (color coding based on screening criteria values).

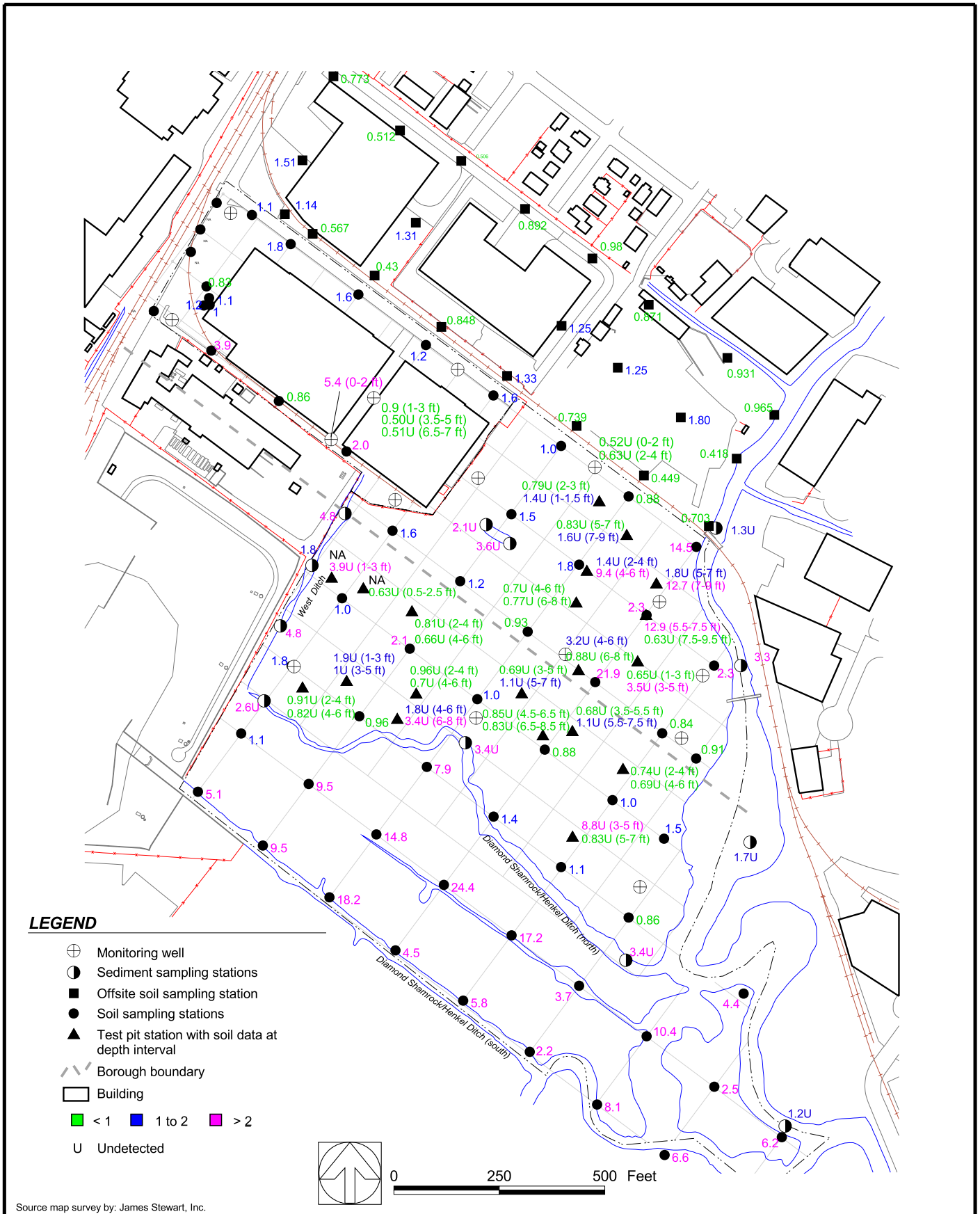


Figure 4-6. Thallium concentrations (mg/kg) in surface and subsurface soils and sediments (color coding based on screening criteria values).

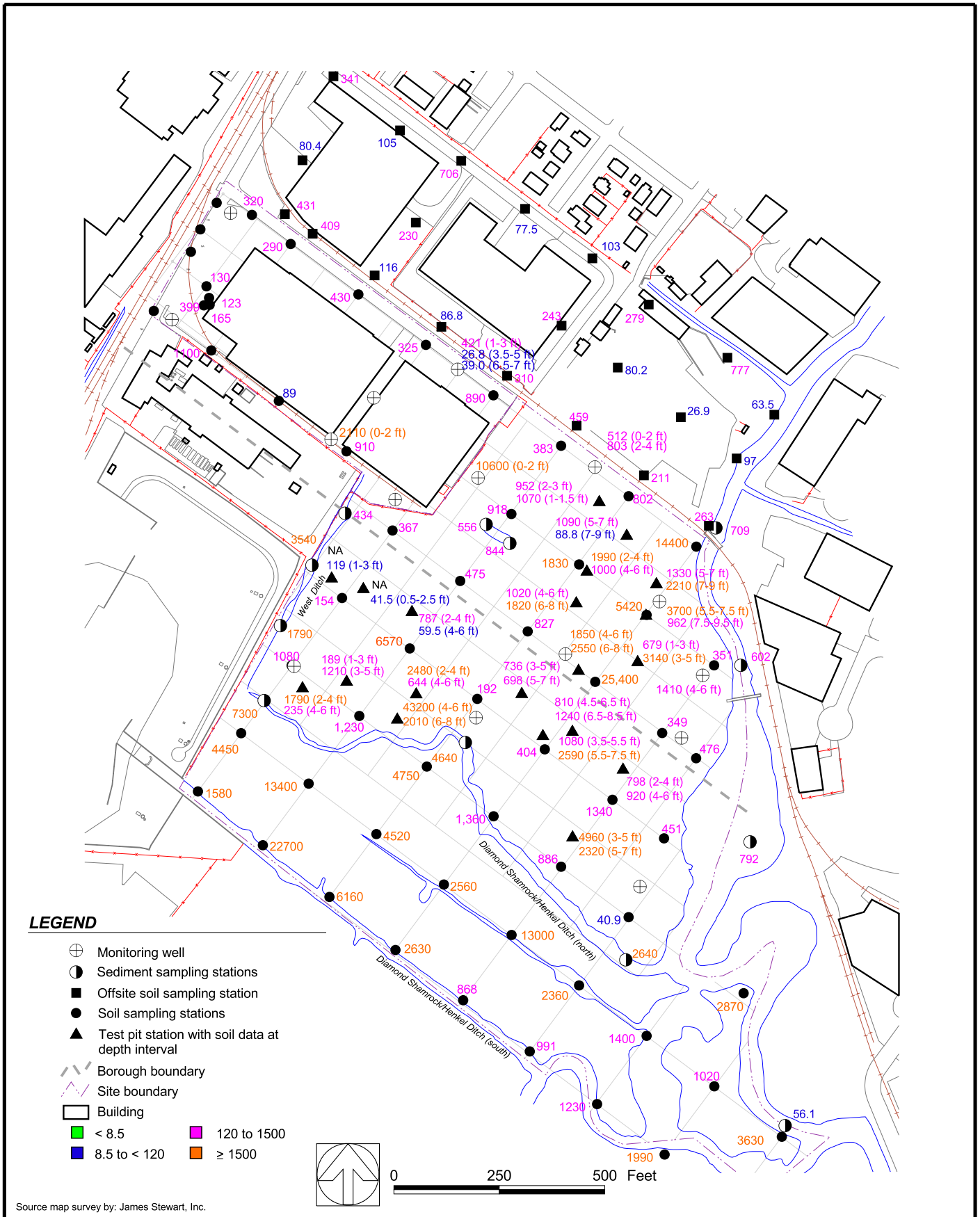


Figure 4-7. Zinc concentrations (mg/kg) in surface and subsurface soils and sediments (color coding based on screening criteria values).

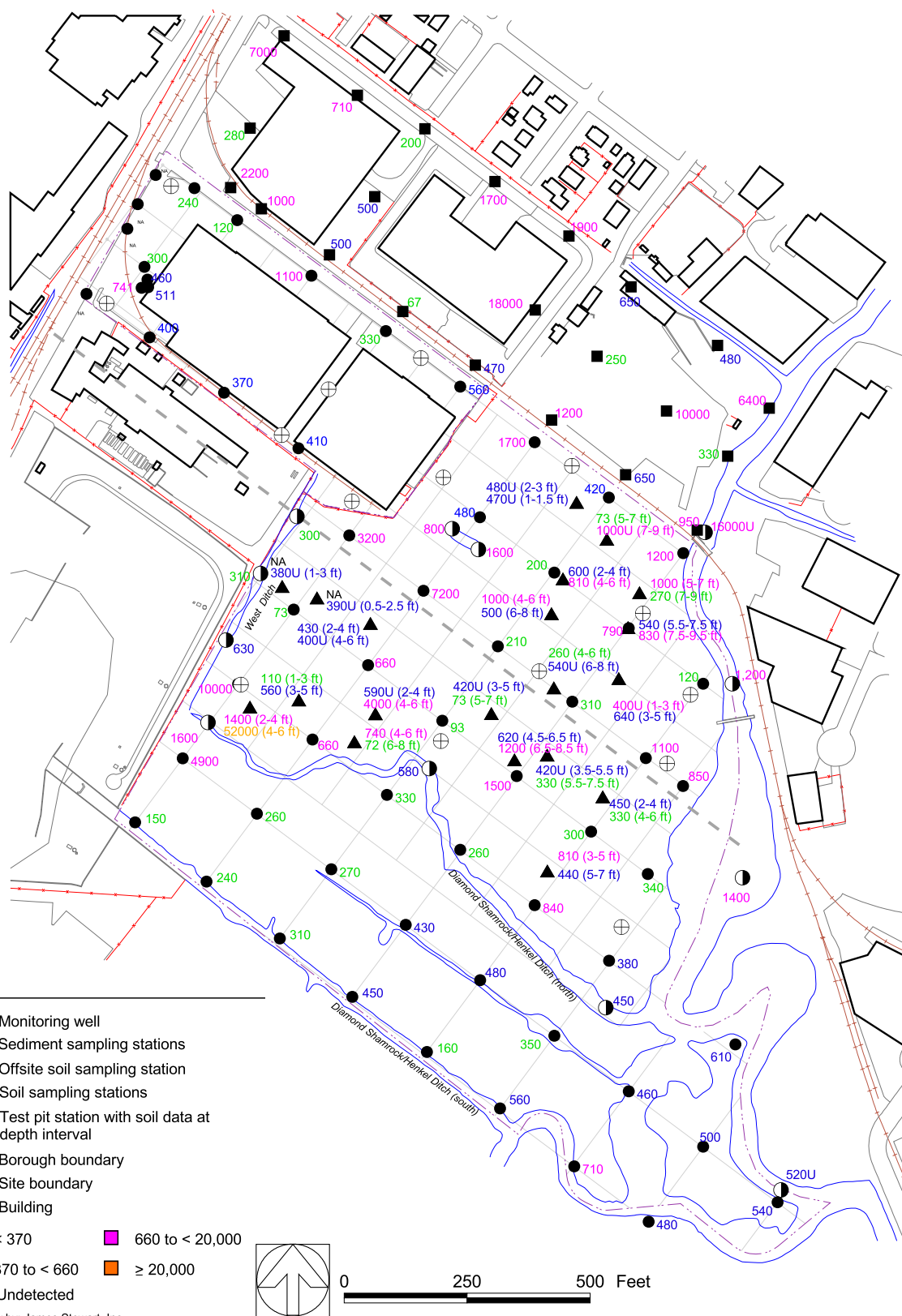


Figure 4-8. Benzo(a)pyrene concentrations ($\mu\text{g/kg}$) in surface and subsurface soils and sediments (color coding based on screening criteria values).

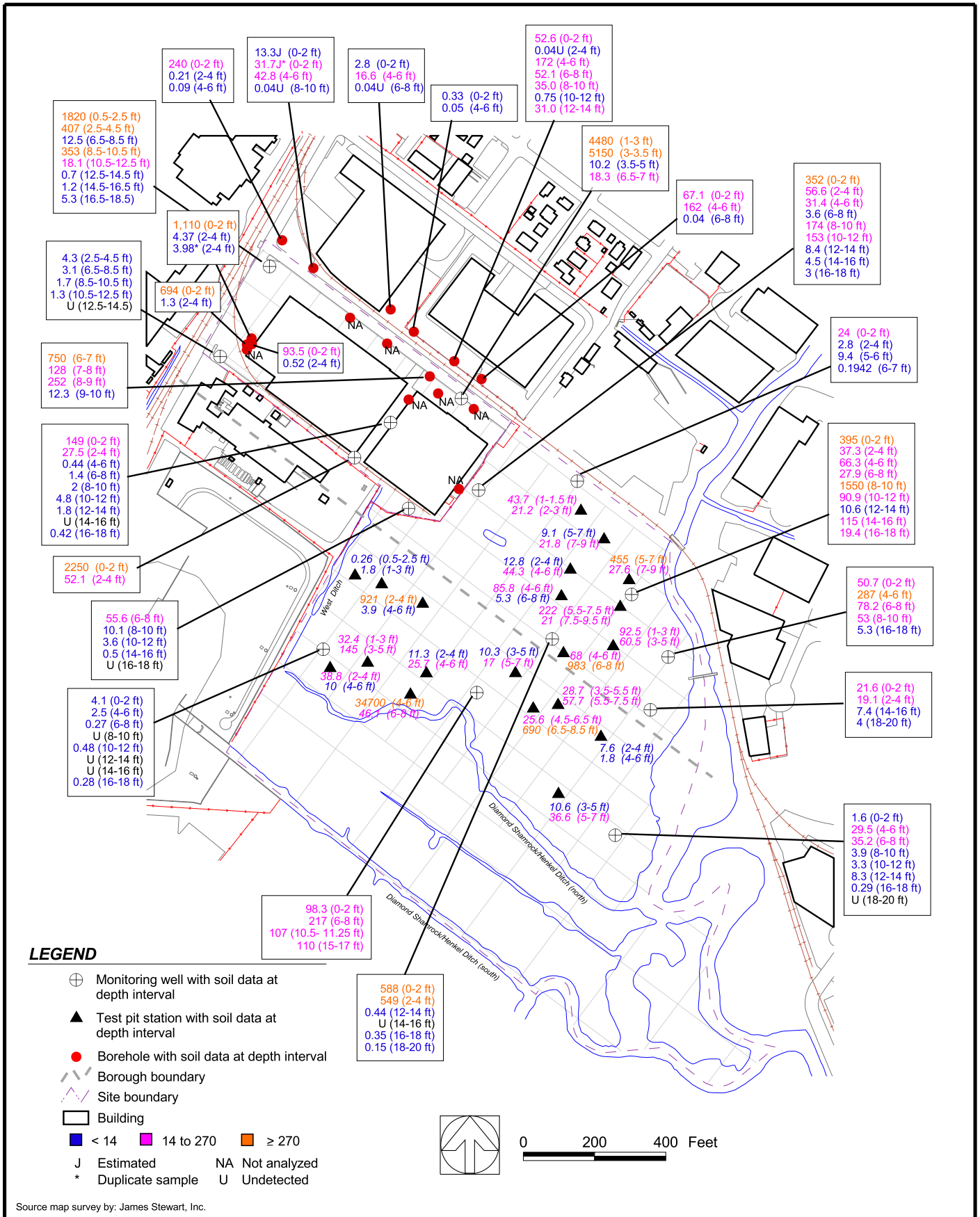


Figure 4-9. Mercury concentrations (mg/kg) in soils from test pits and boreholes (color coding based on screening criteria values).

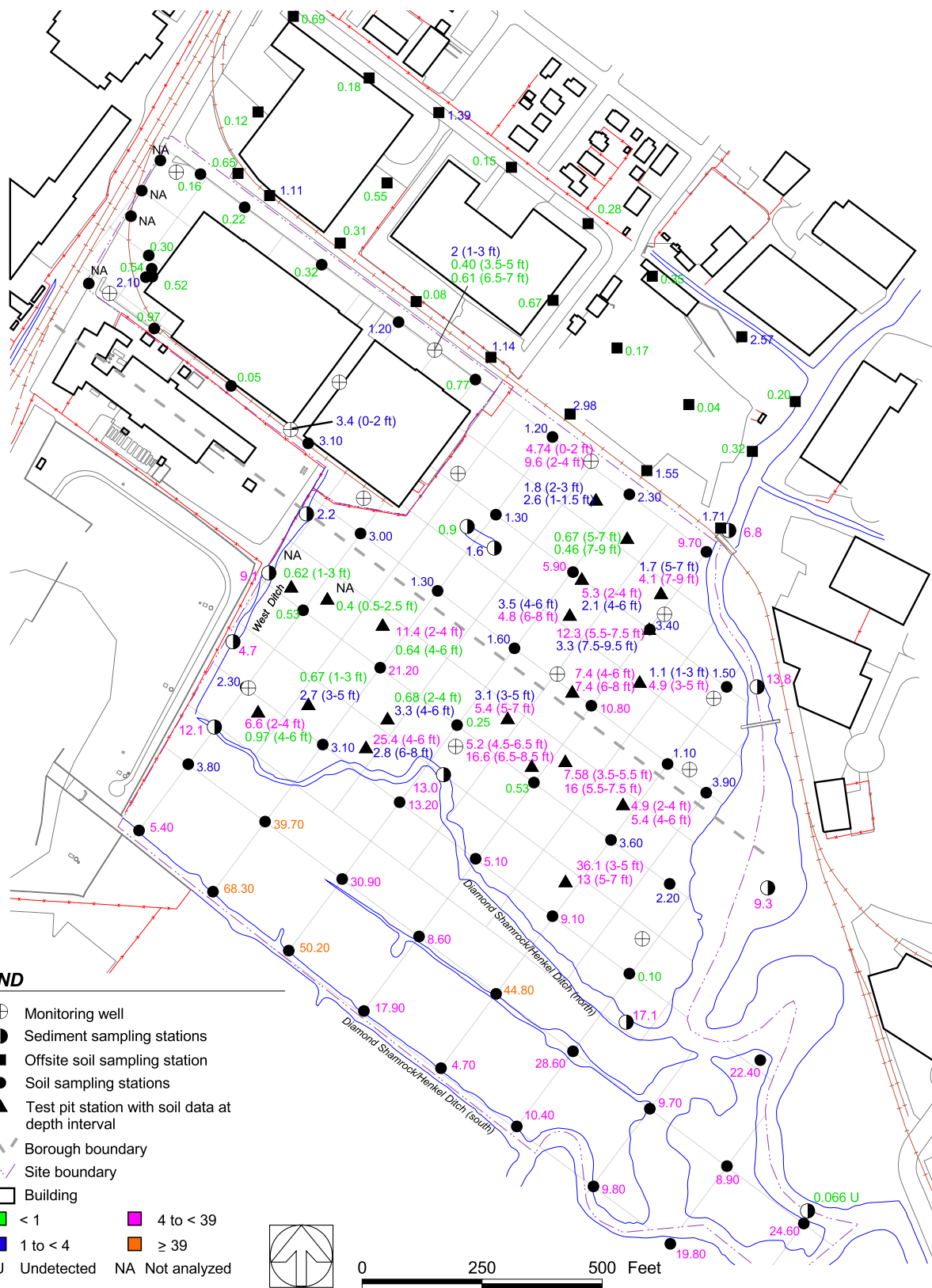


Figure 4-10. Cadmium concentrations (mg/kg) in surface and subsurface soils and sediments (color coding based on screening criteria values).

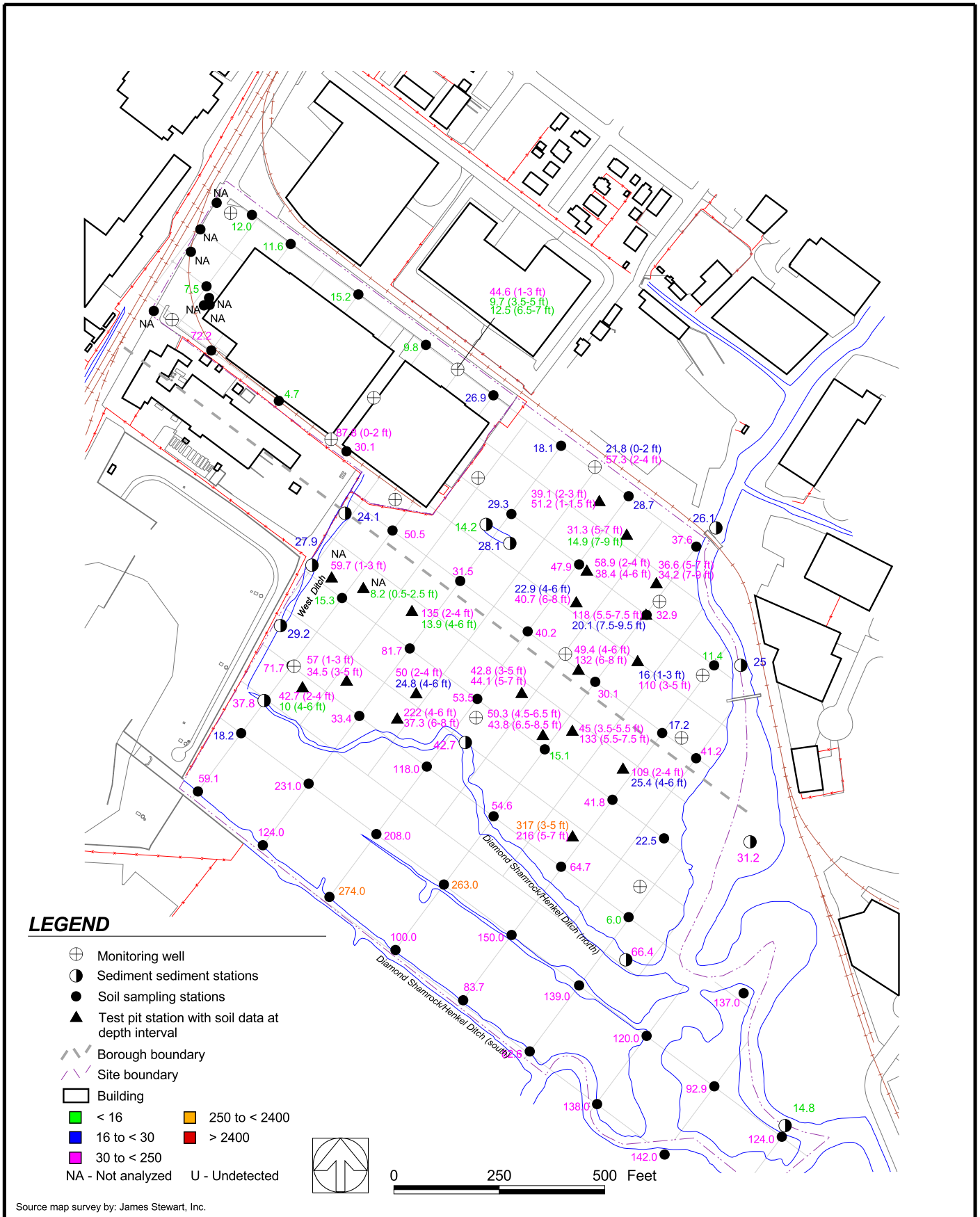
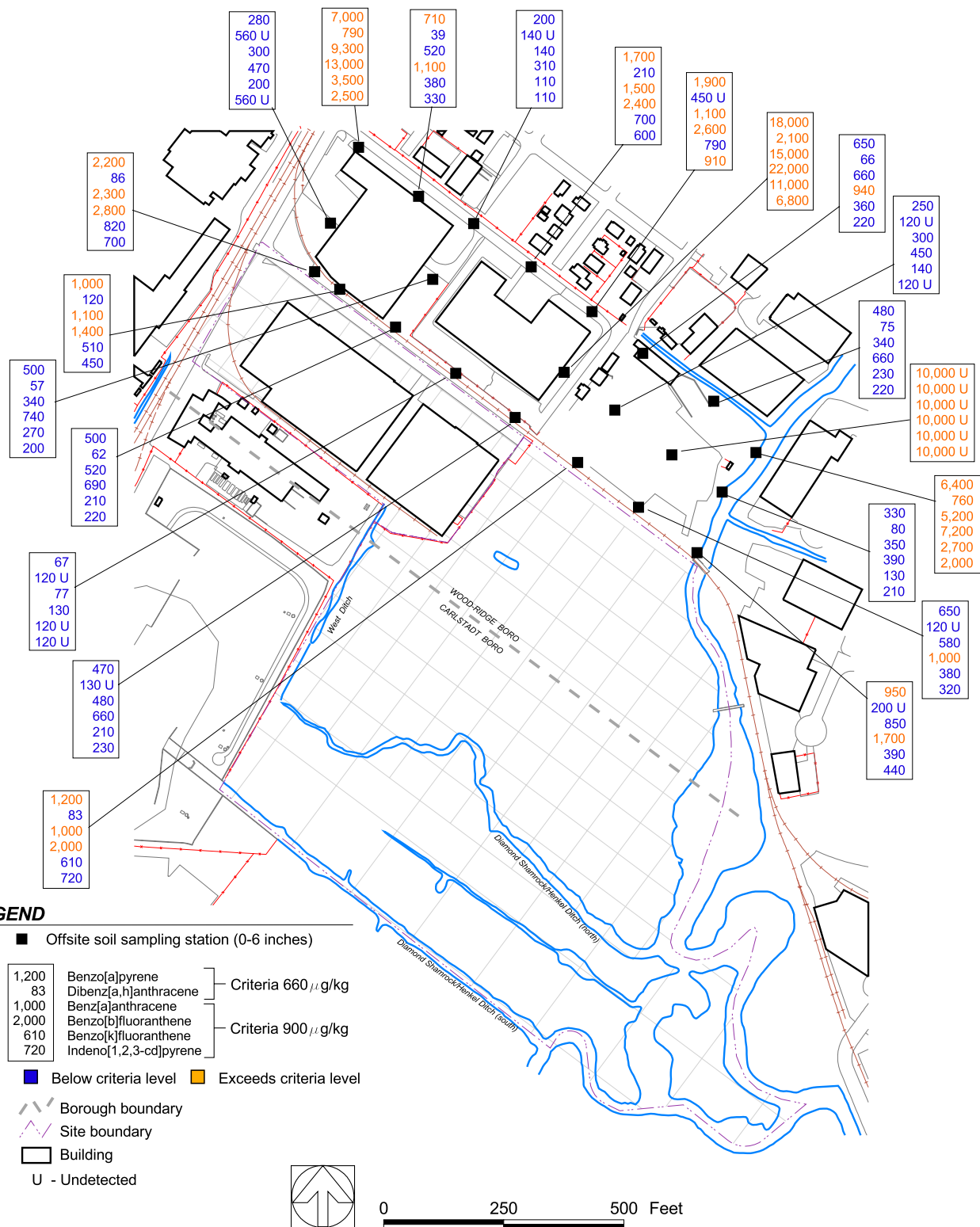


Figure 4-11. Nickel concentrations (mg/kg) in surface and subsurface soils and sediments (color coding based on screening criteria values).



Source map survey by: James Stewart, Inc.

Figure 4-12. PAH concentrations ($\mu\text{g/kg}$) in offsite soils (color coding based on screening criteria values).

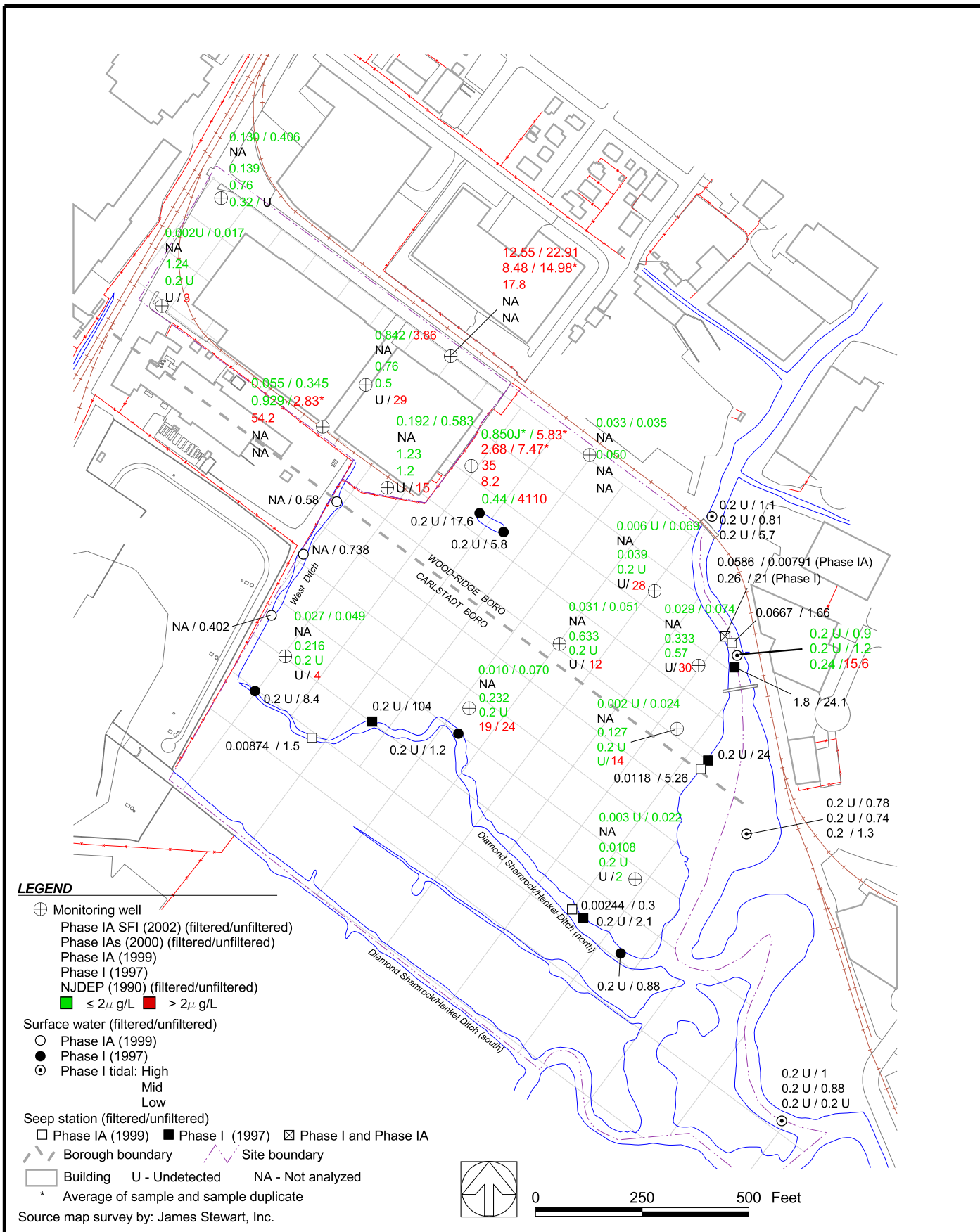


Figure 4-13. Mercury concentrations (μ g/L) in surface water, seeps, and groundwater.

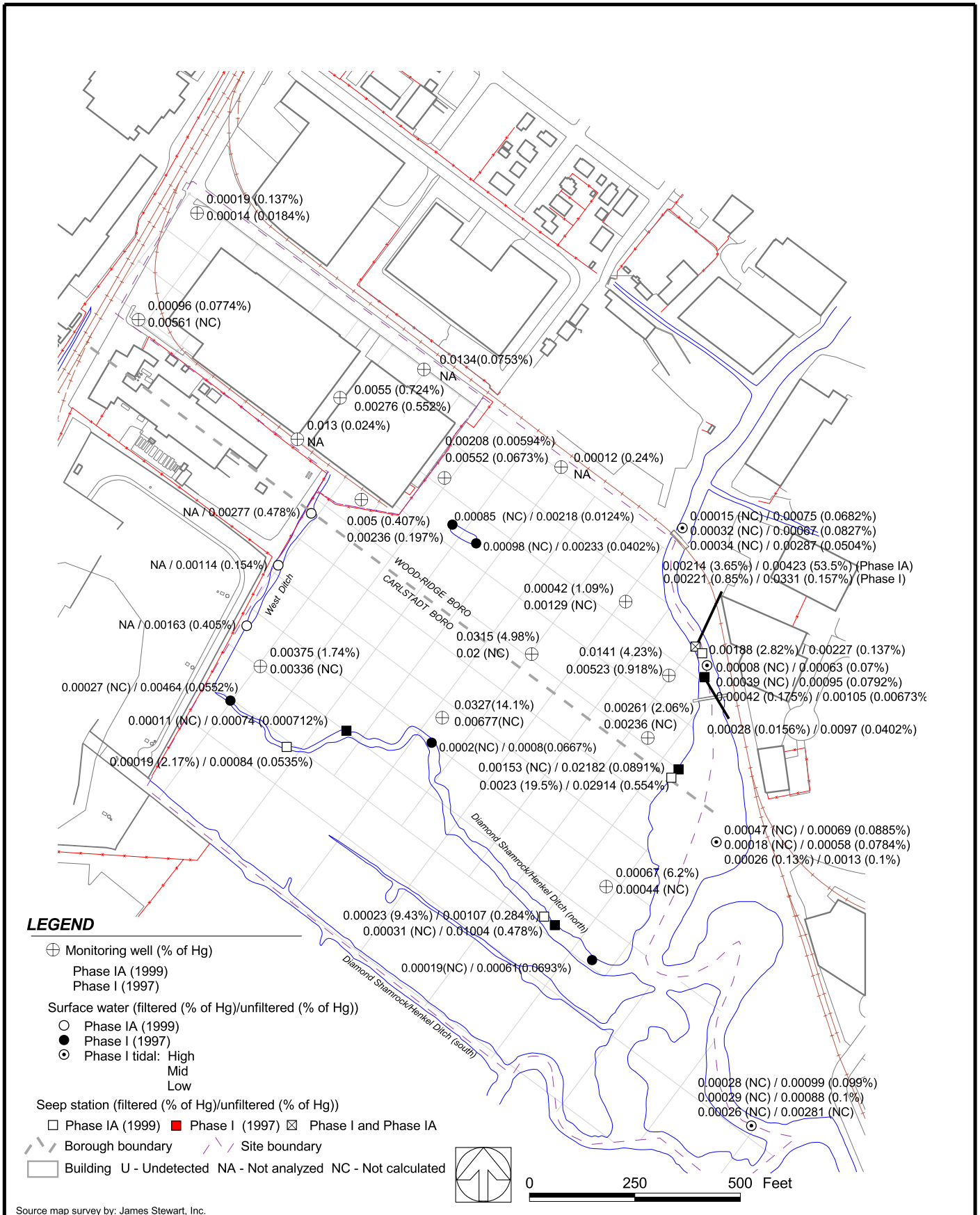


Figure 4-14. Methylmercury concentrations ($\mu\text{g/L}$ and as percentage of total mercury) in surface water, seeps, and groundwater.

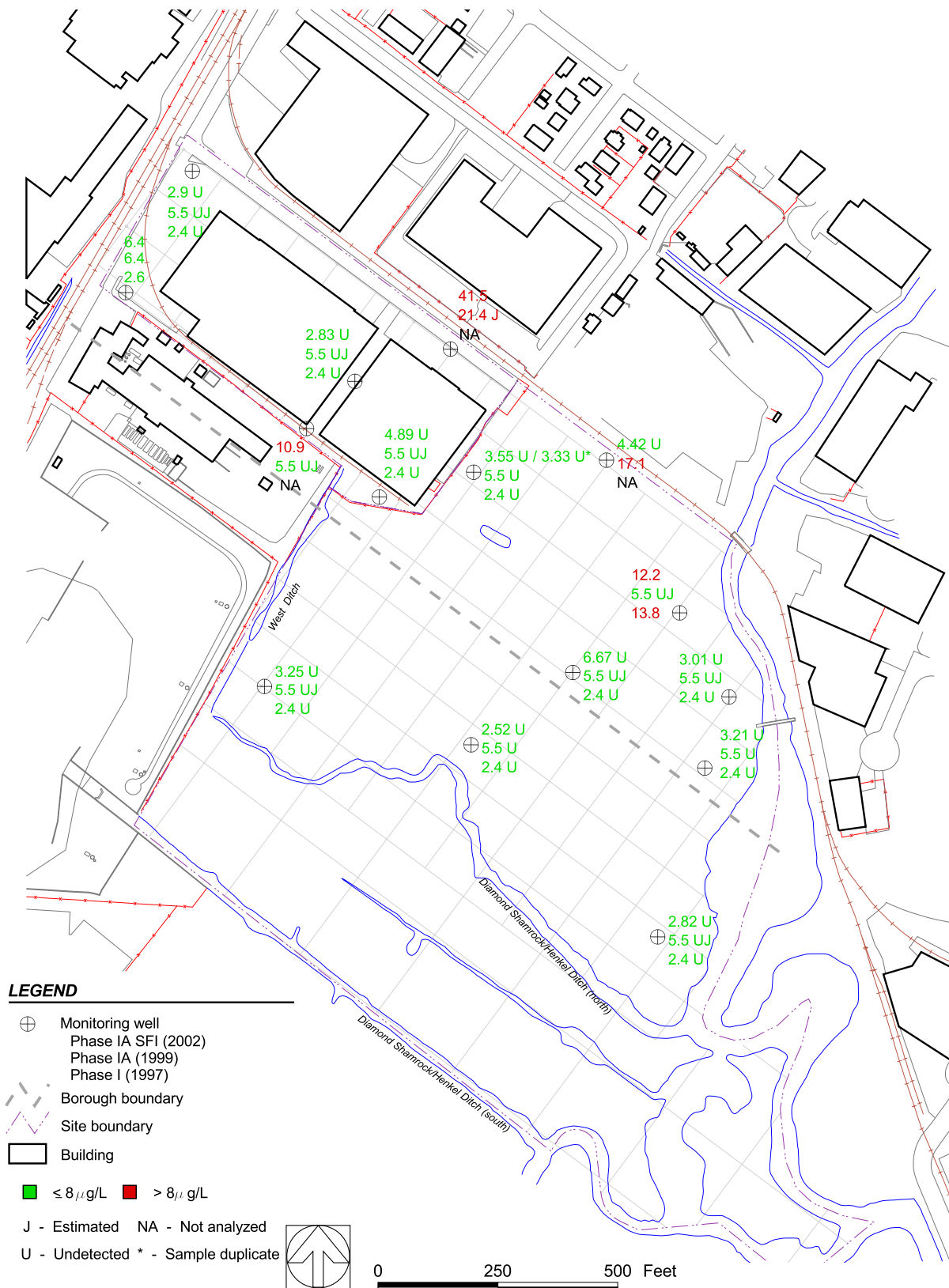
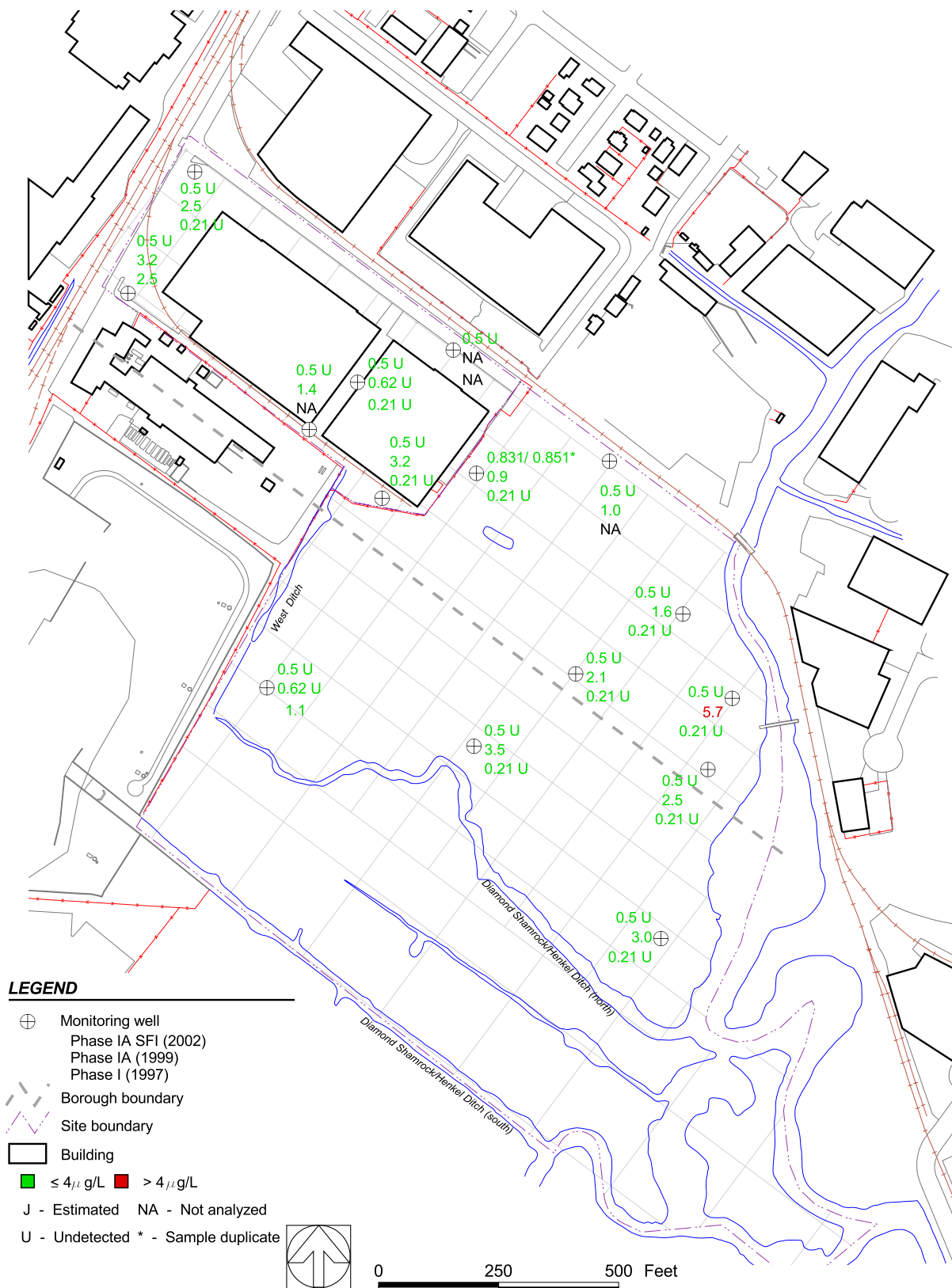


Figure 4-15. Arsenic concentrations (μ g/L) in groundwater (color coding based on screening criteria values).



Source map survey by: James Stewart, Inc.

Figure 4-16. Cadmium concentrations ($\mu\text{g/L}$) in groundwater (color coding based on screening criteria values).

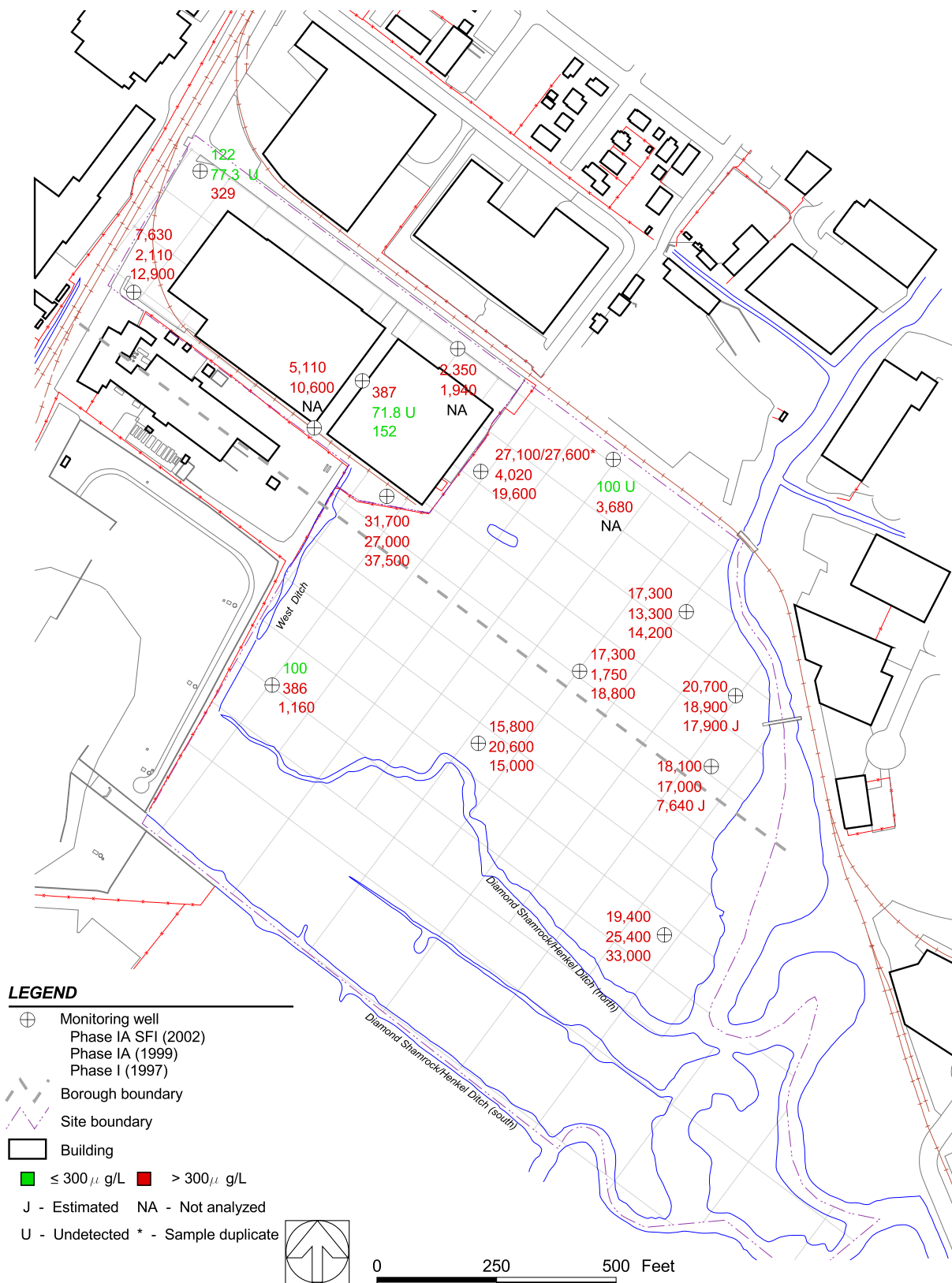
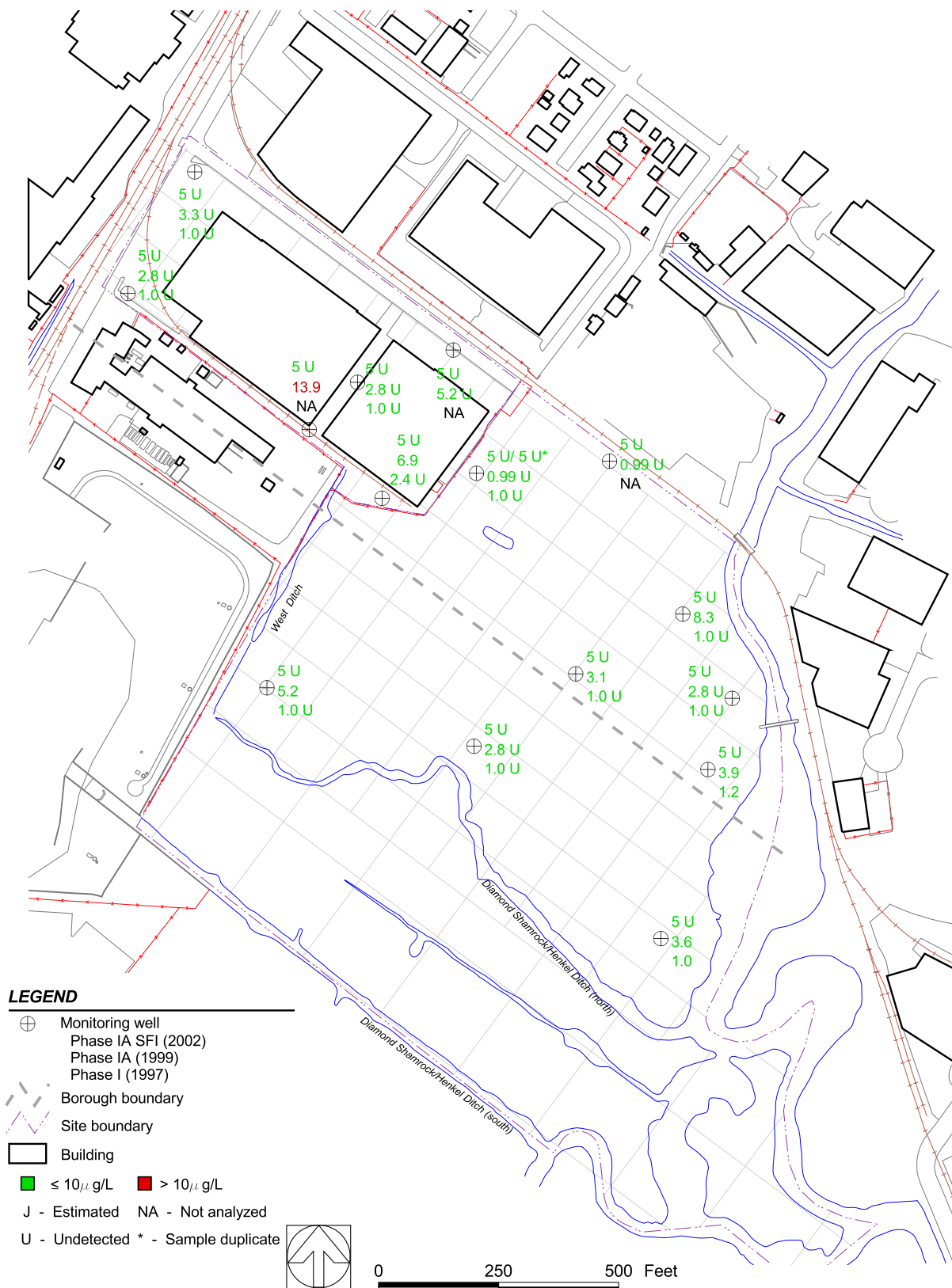
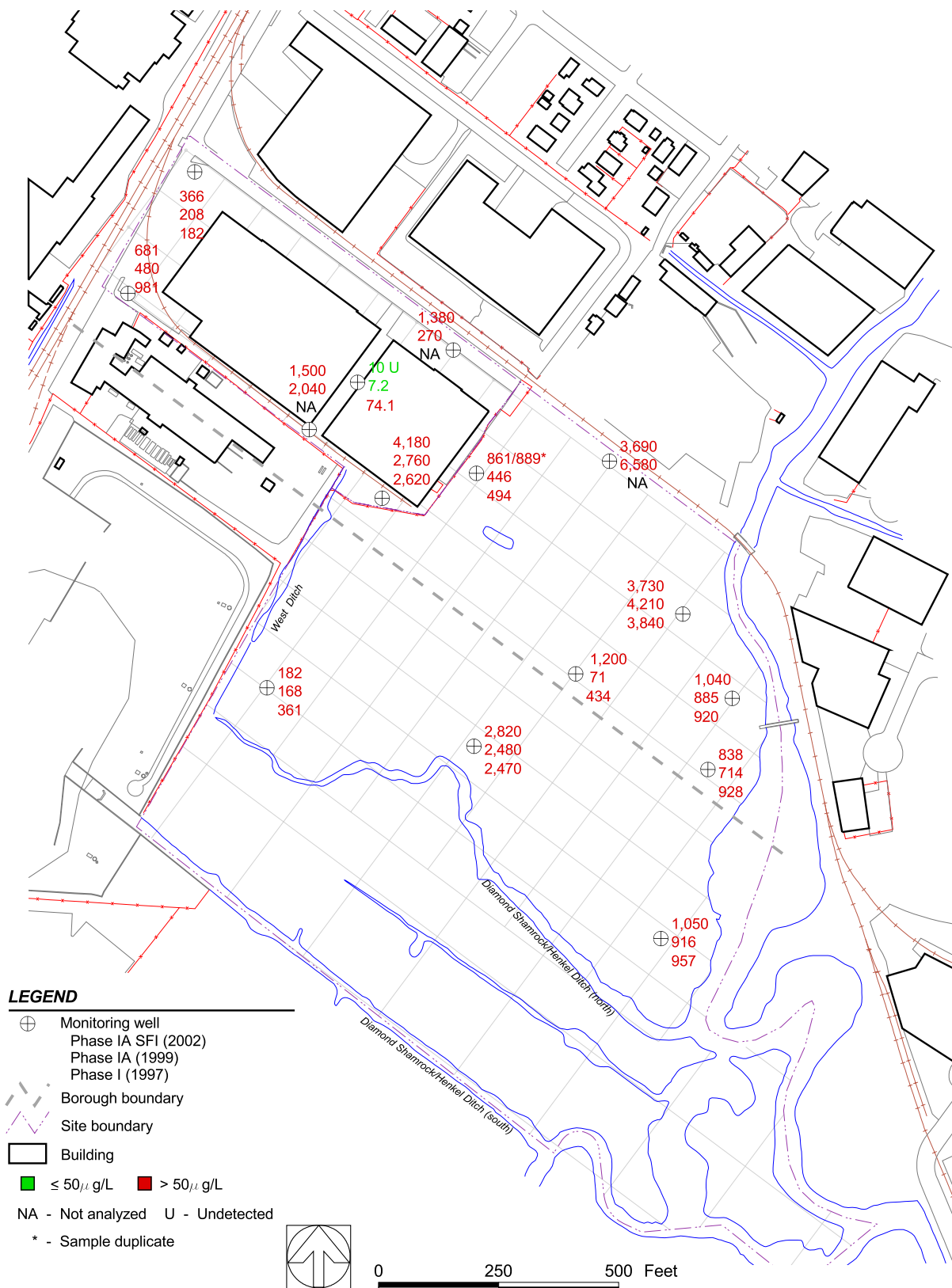


Figure 4-17. Iron concentrations ($\mu\text{g/L}$) in groundwater (color coding based on screening criteria values).



Source map survey by: James Stewart, Inc.

Figure 4-18. Lead concentrations ($\mu\text{g/L}$) in groundwater (color coding based on screening criteria values).



Source map survey by: James Stewart, Inc.

Figure 4-19. Manganese concentrations ($\mu\text{g/L}$) in groundwater (color coding based on screening criteria values).

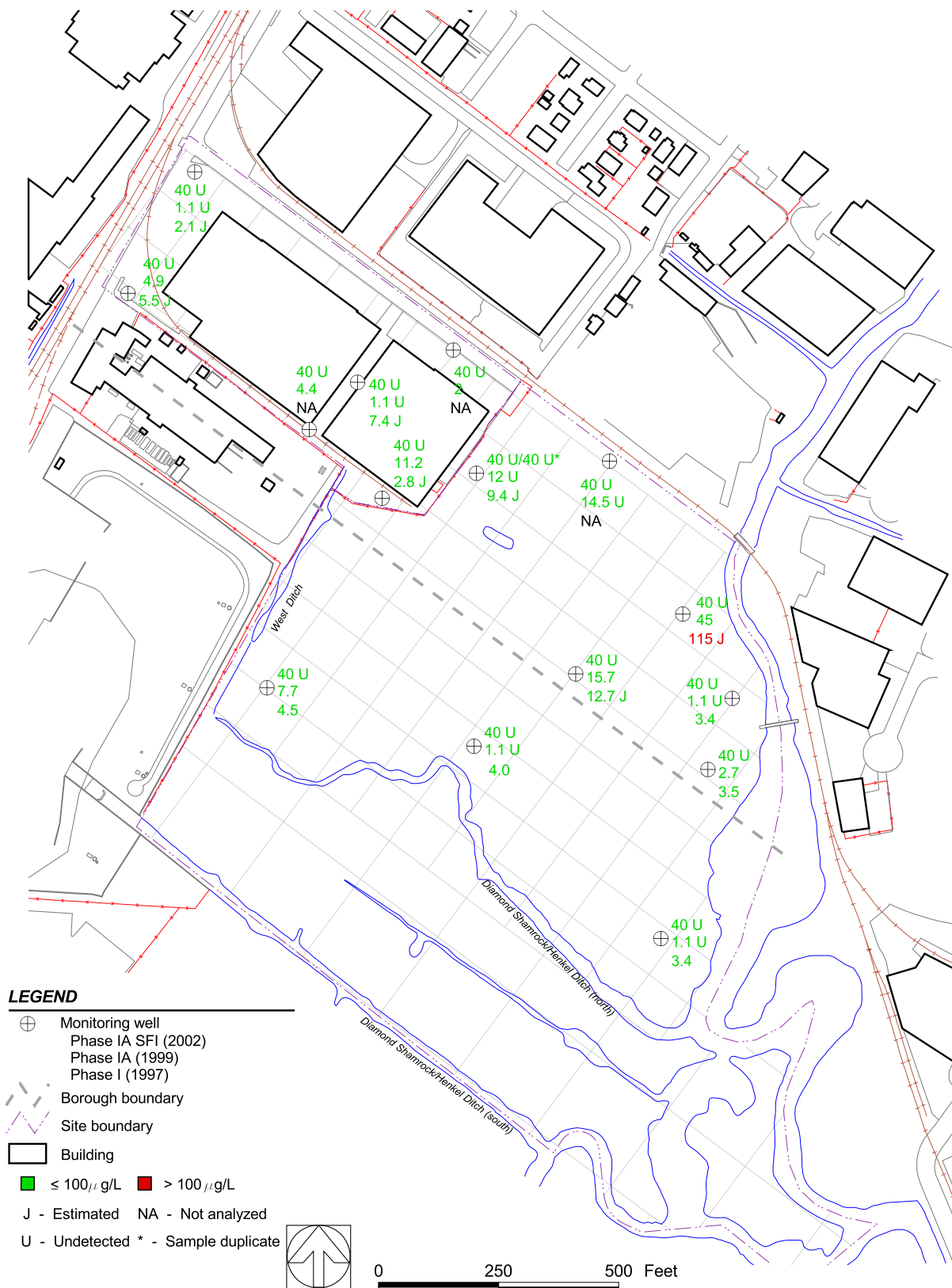
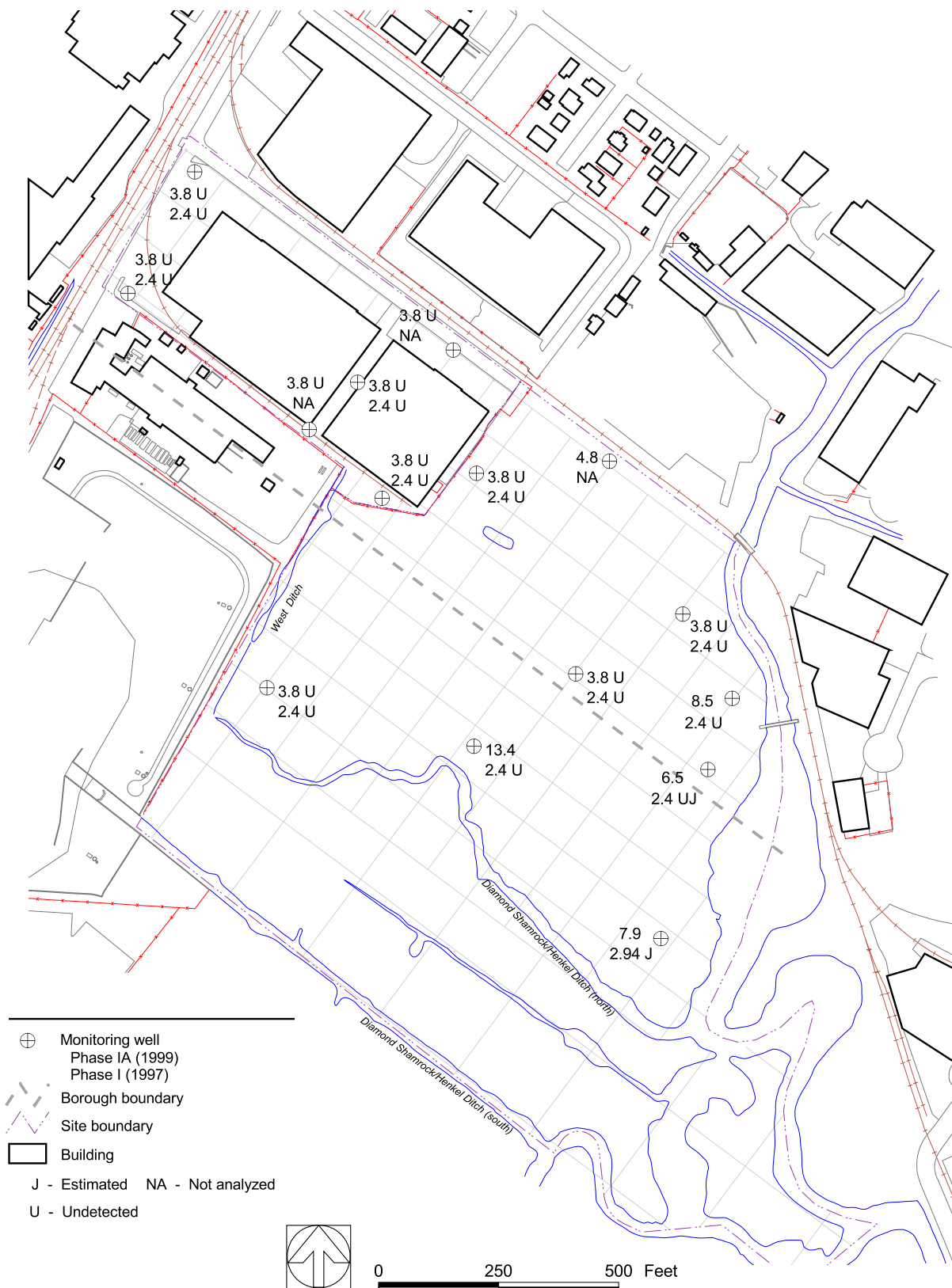


Figure 4-20. Nickel concentrations ($\mu\text{g/L}$) in groundwater (color coding based on screening criteria values).



Source map survey by: James Stewart, Inc.

Figure 4-21. Selenium concentrations ($\mu\text{g/L}$) in groundwater (no screening criteria available).

LEGEND

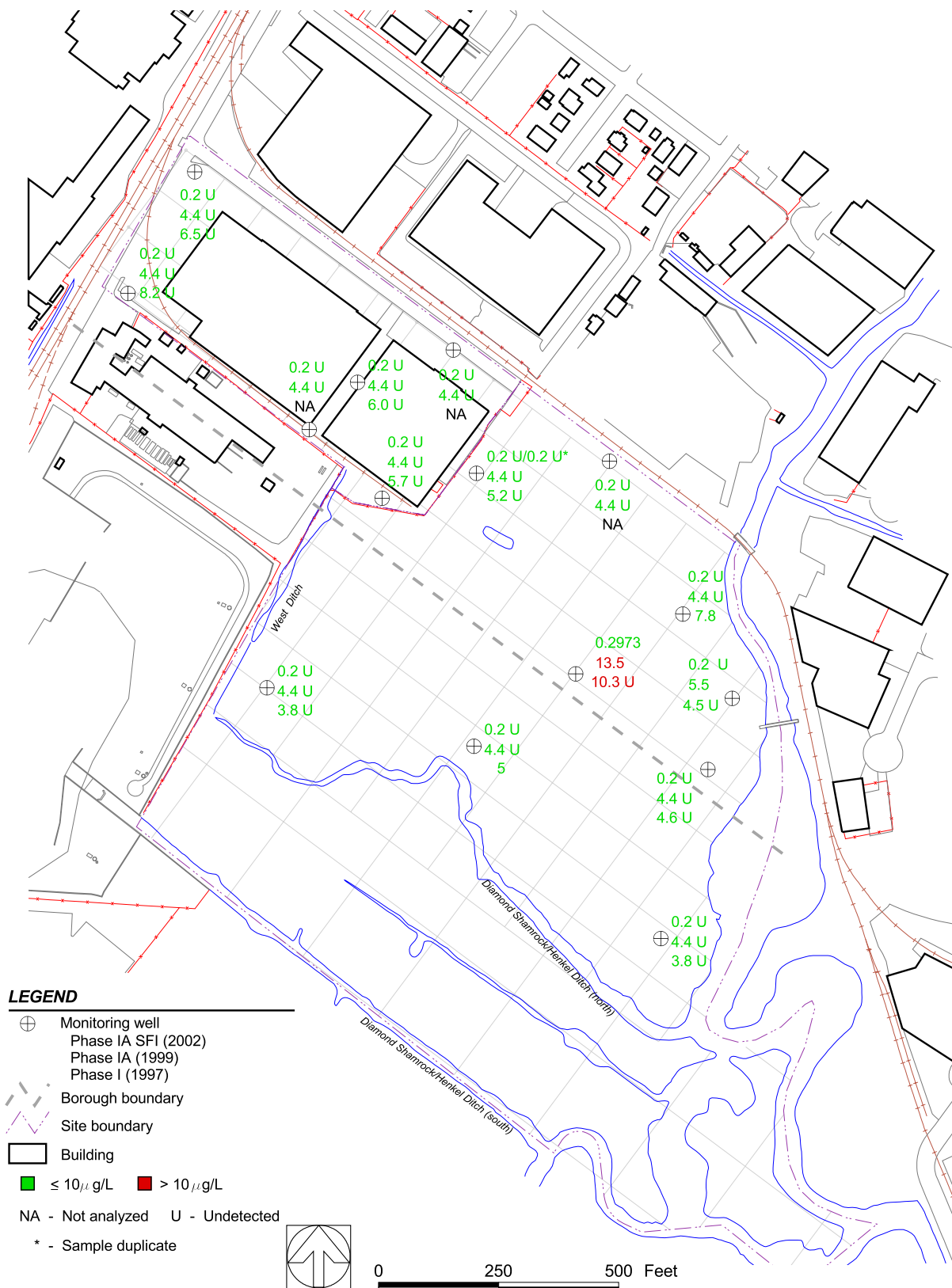
- ⊕ Monitoring well
- Phase I (1997)
- Borough boundary
- - - Site boundary
- Building
- ≤ 50,000 $\mu\text{g/L}$ ■ > 50,000 $\mu\text{g/L}$
- J - Estimated NA - Not analyzed
- U - Undetected



0 250 500 Feet

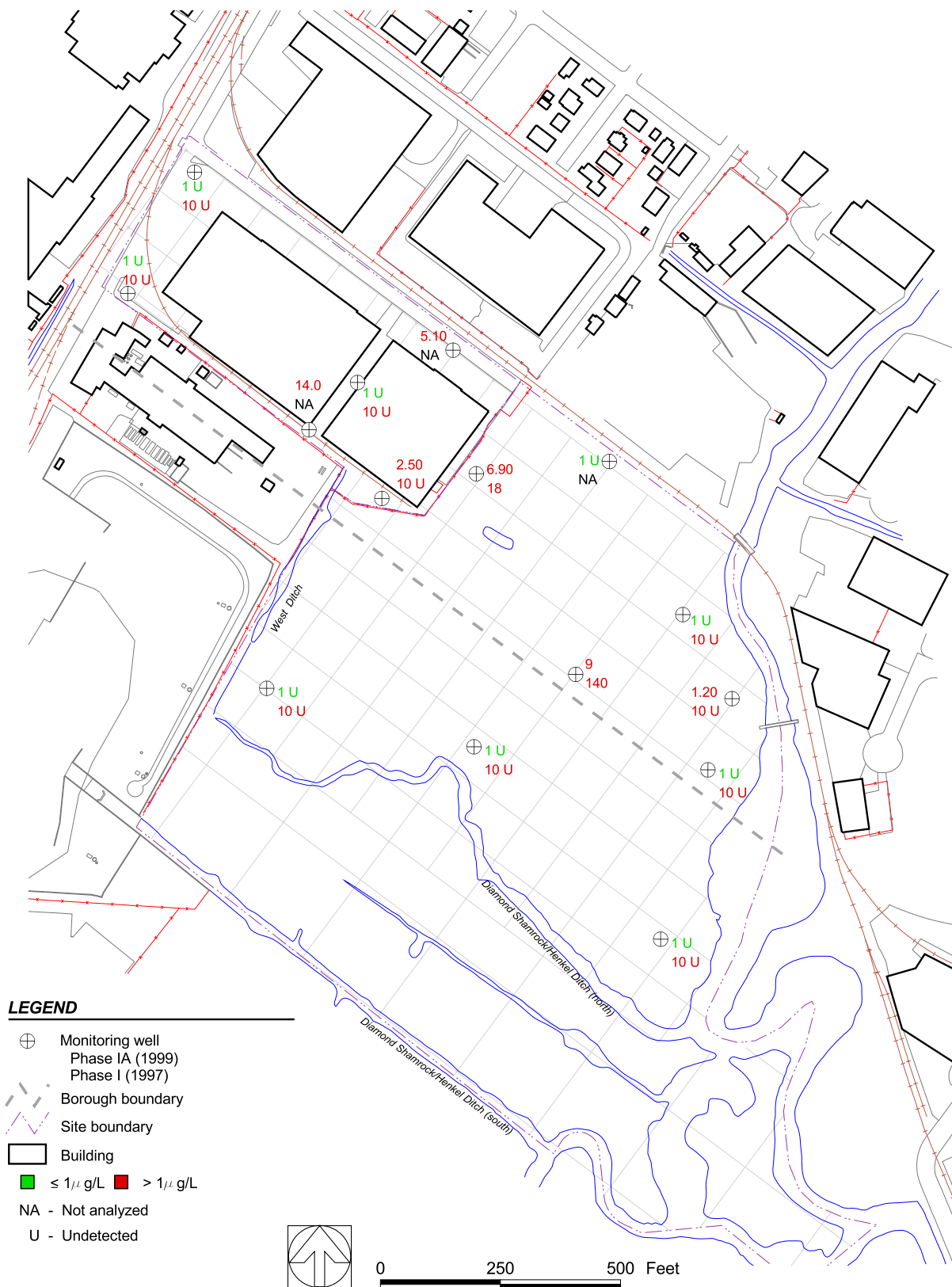
Source map survey by: James Stewart, Inc.

Figure 4-22. Sodium concentrations ($\mu\text{g/L}$) in groundwater (color coding based on screening criteria values).



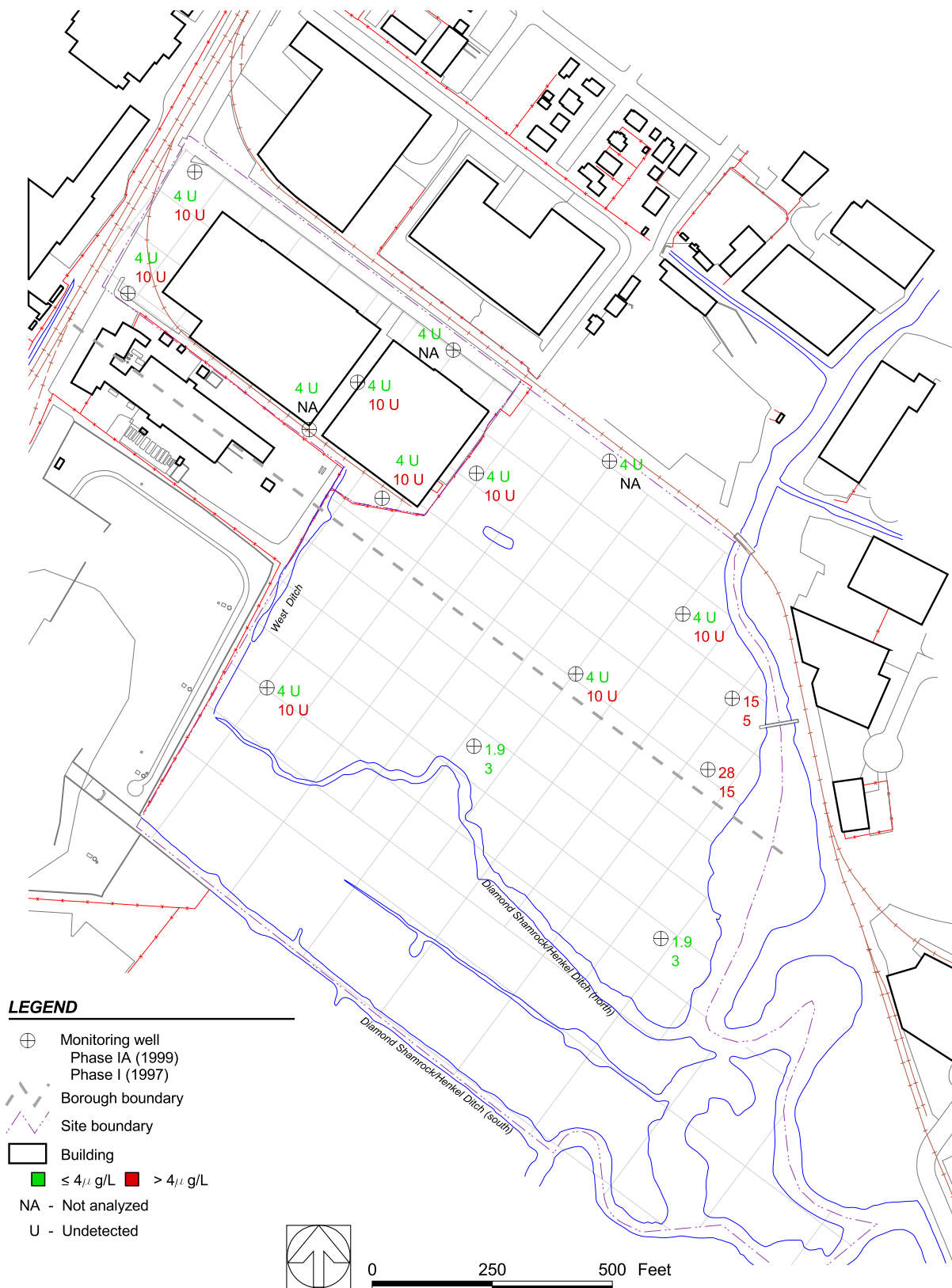
Source map survey by: James Stewart, Inc.

Figure 4-23. Thallium concentrations ($\mu\text{g/L}$) in groundwater (color coding based on screening criteria values).



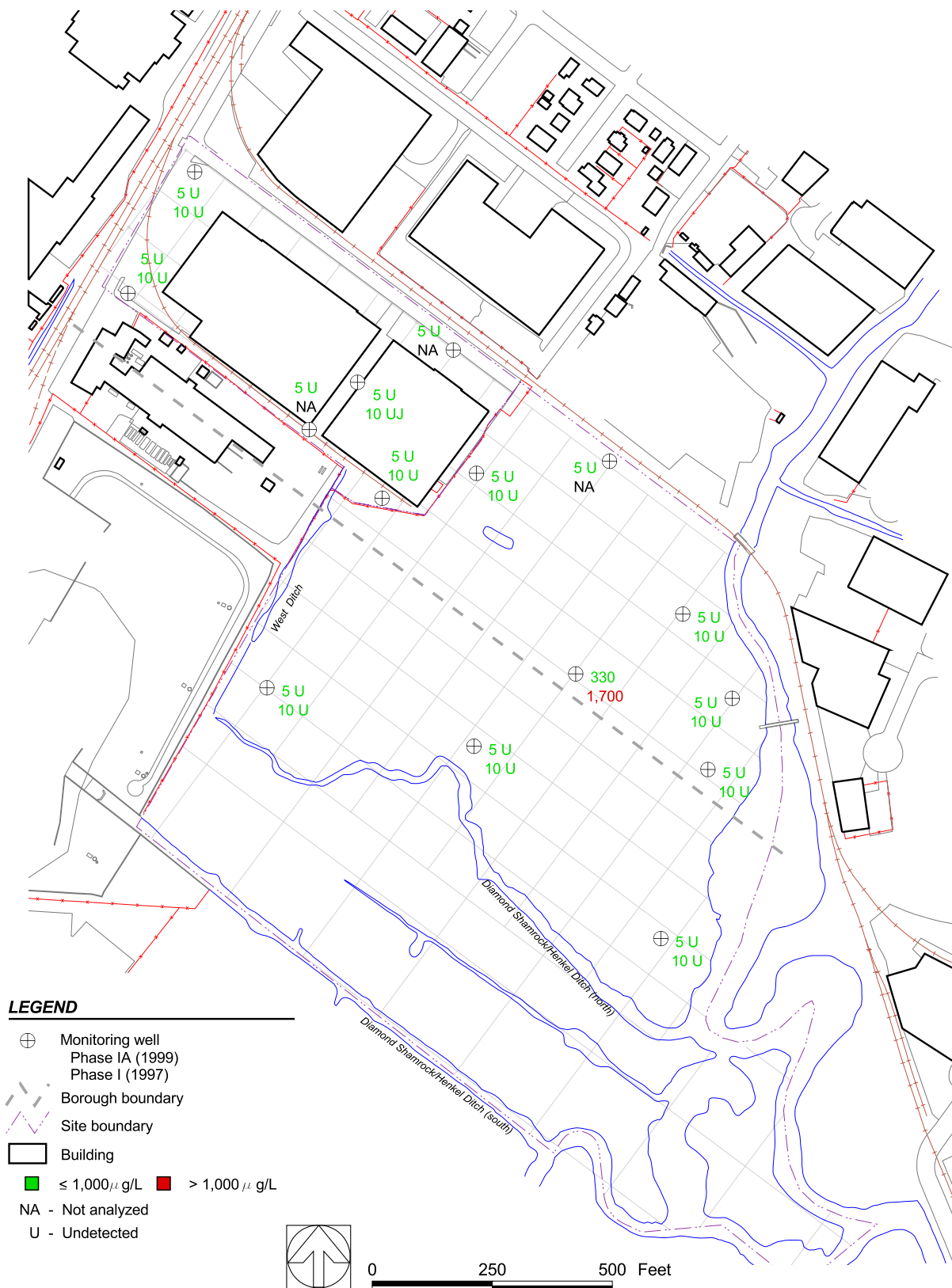
Source map survey by: James Stewart, Inc.

Figure 4-24. Benzene concentrations ($\mu\text{g/L}$) in groundwater (color coding based on screening criteria values).



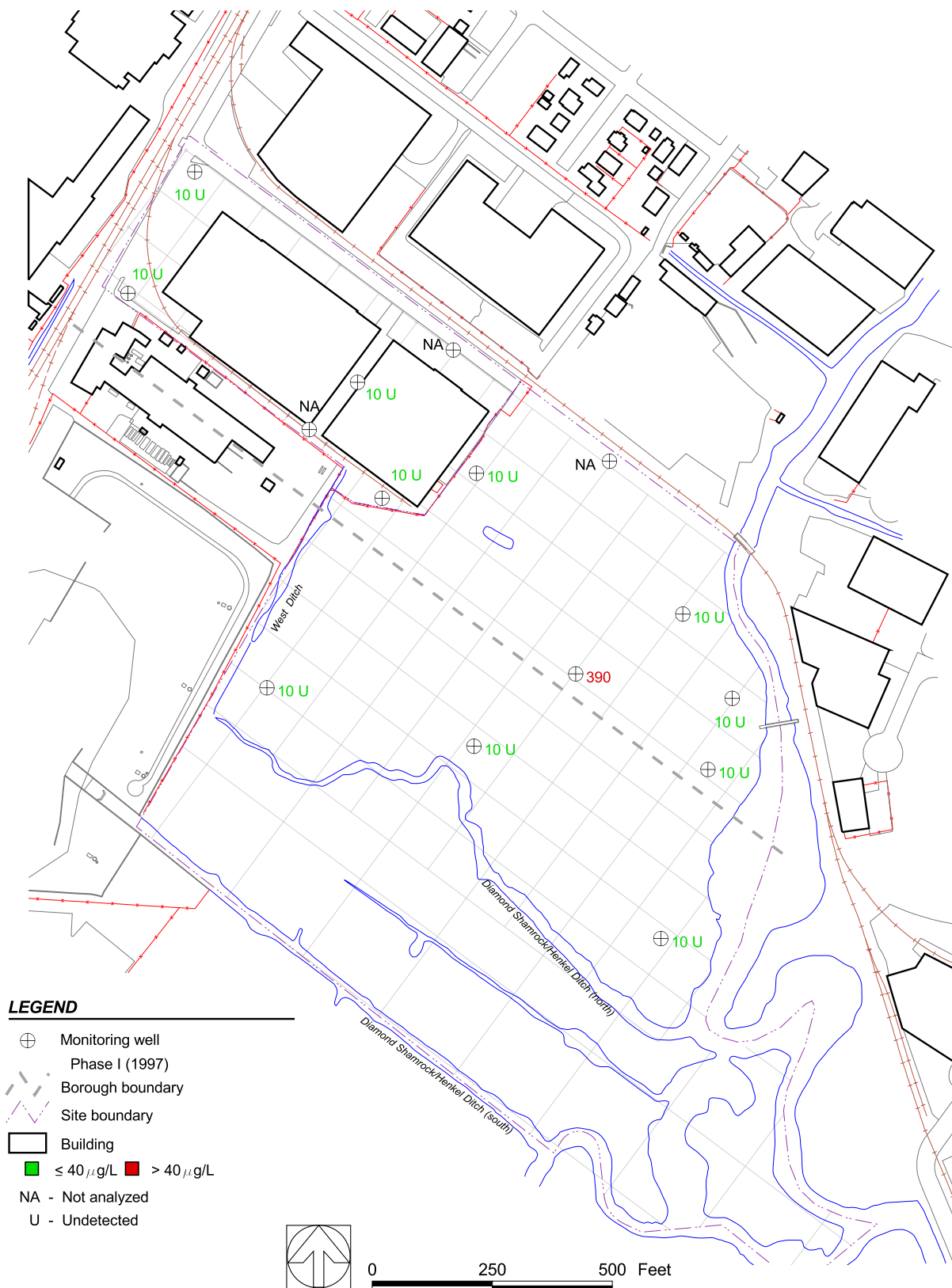
Source map survey by: James Stewart, Inc.

Figure 4-25. Chlorobenzene concentrations (μ g/L) in groundwater (color coding based on screening criteria values).



Source map survey by: James Stewart, Inc.

Figure 4-26. Toluene concentrations (μ g/L) in groundwater (color coding based on screening criteria values).



Source map survey by: James Stewart, Inc.

Figure 4-27. Xylene isomer concentrations ($\mu\text{g/L}$) in groundwater (color coding based on screening criteria values).

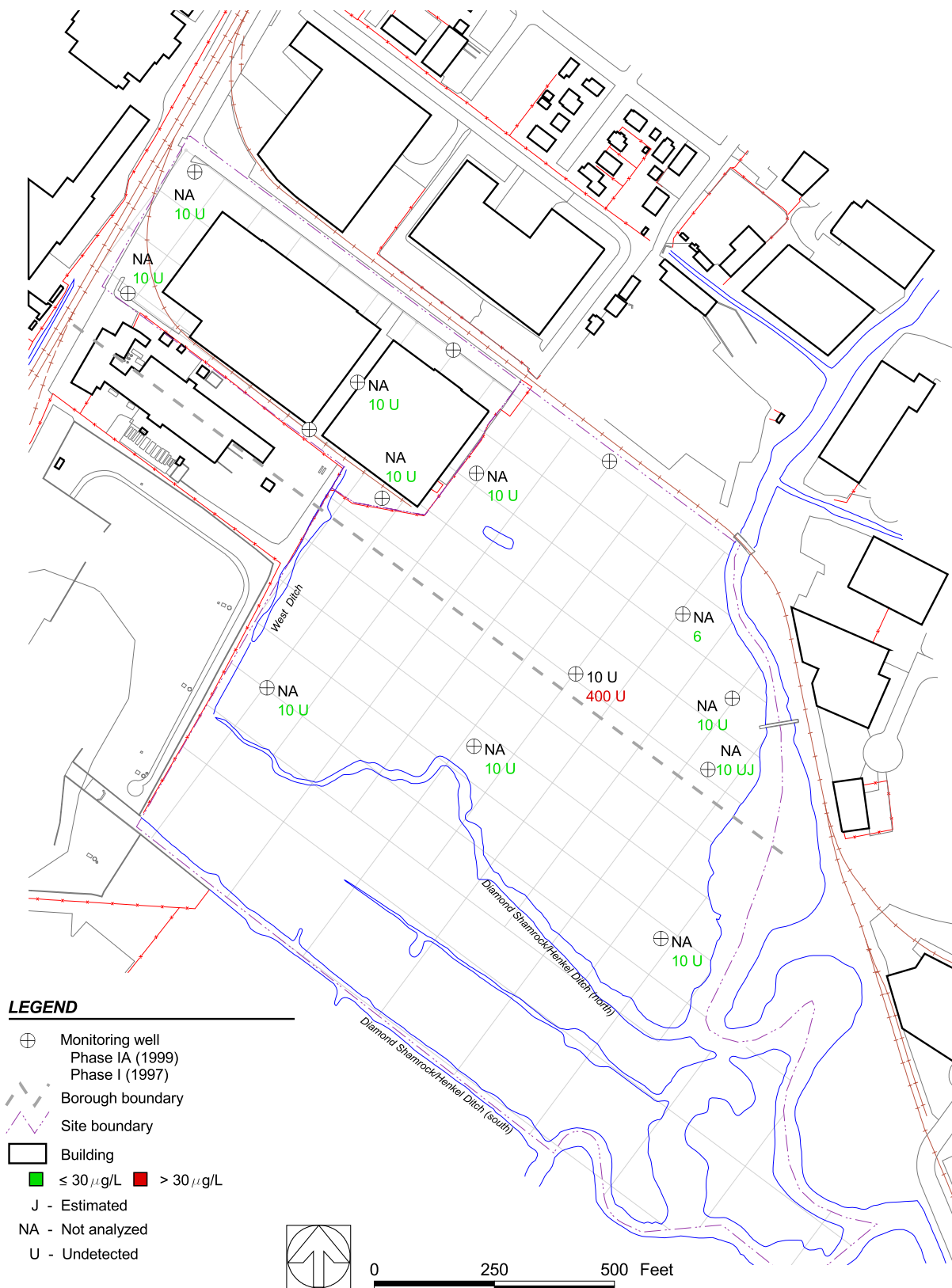


Figure 4-28. bis[2-Ethylhexyl]phthalate concentrations ($\mu\text{g/L}$) in groundwater (color coding based on screening criteria values).

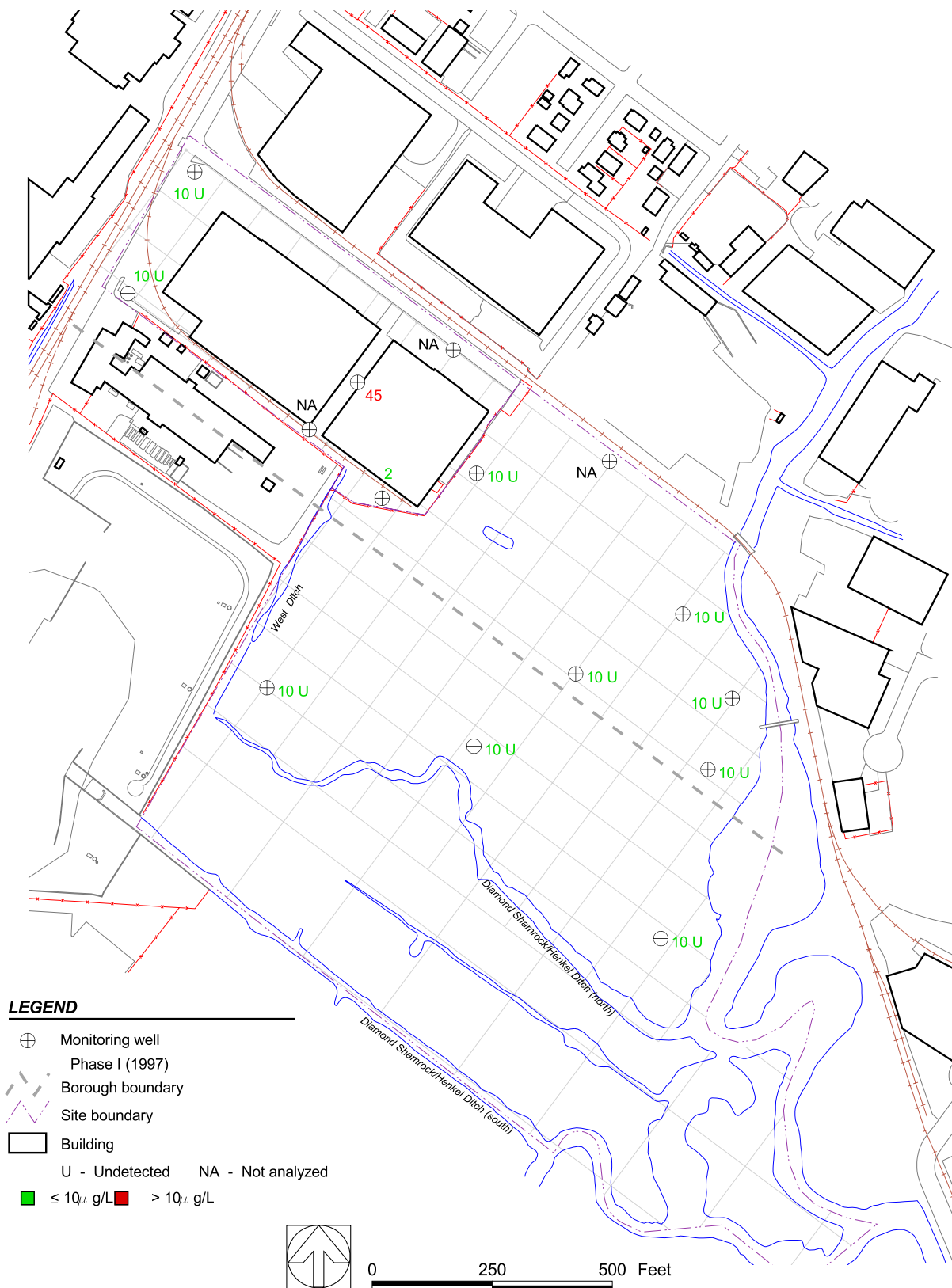
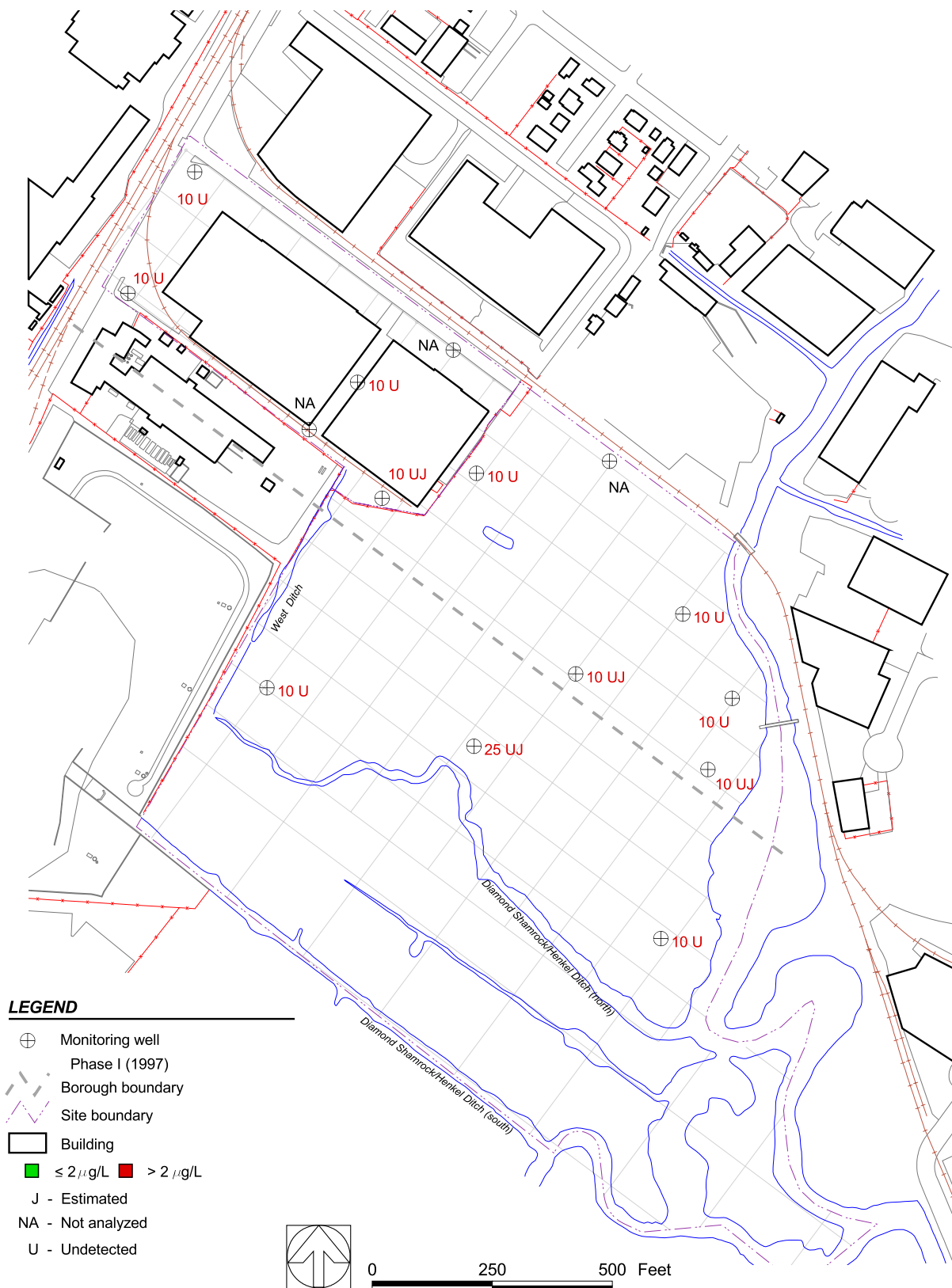


Figure 4-29. 1,2-Dichloroethene isomers (total) concentrations ($\mu\text{g/L}$) in groundwater (color coding based on screening criteria values).



Source map survey by: James Stewart, Inc.

Figure 4-30. 1,1,2,2-Tetrachloroethane concentrations ($\mu\text{g/L}$) in groundwater (color coding based on screening criteria values).

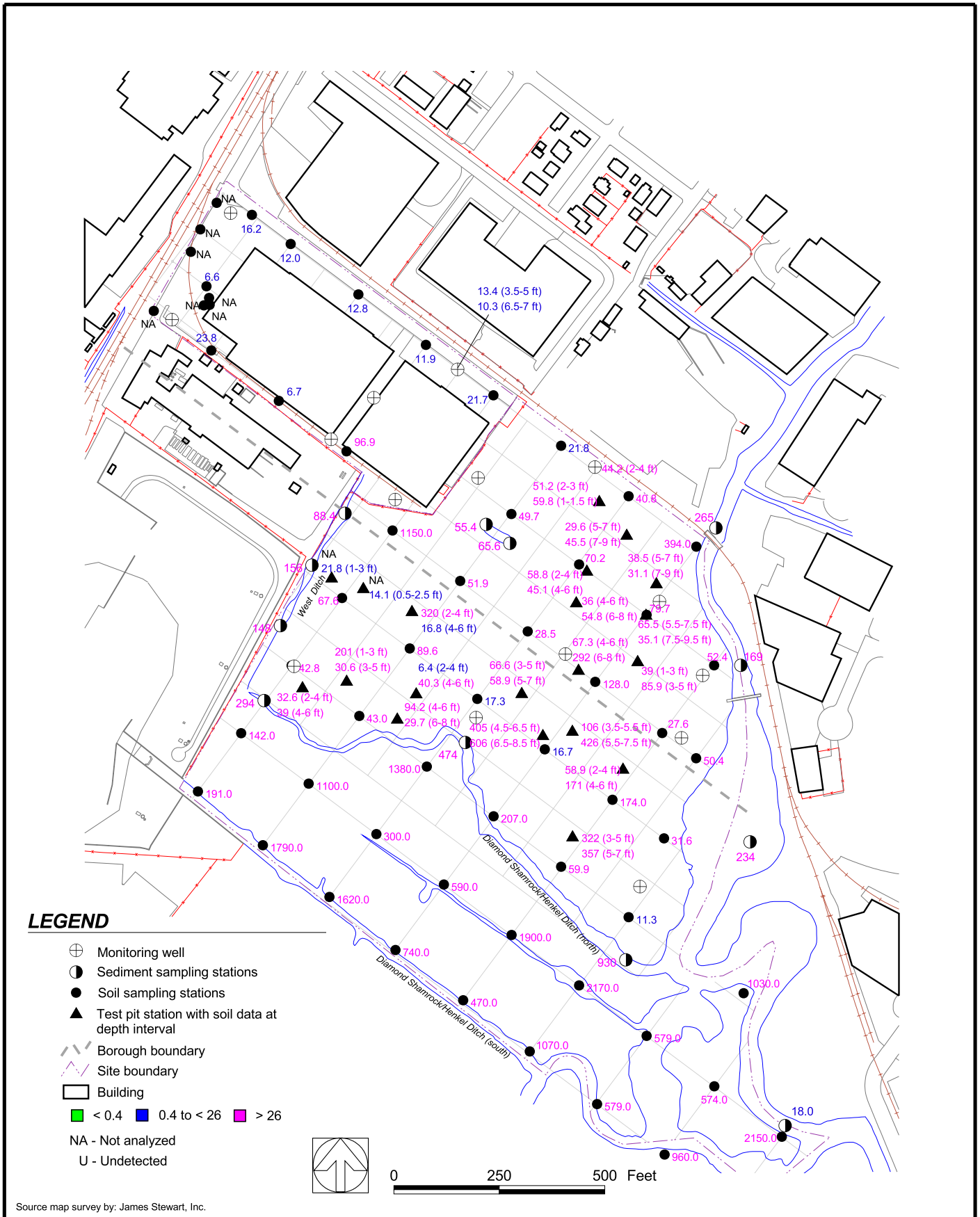


Figure 4-31. Chromium concentrations (mg/kg) in surface and subsurface soils and sediments (color coding based on screening criteria values).

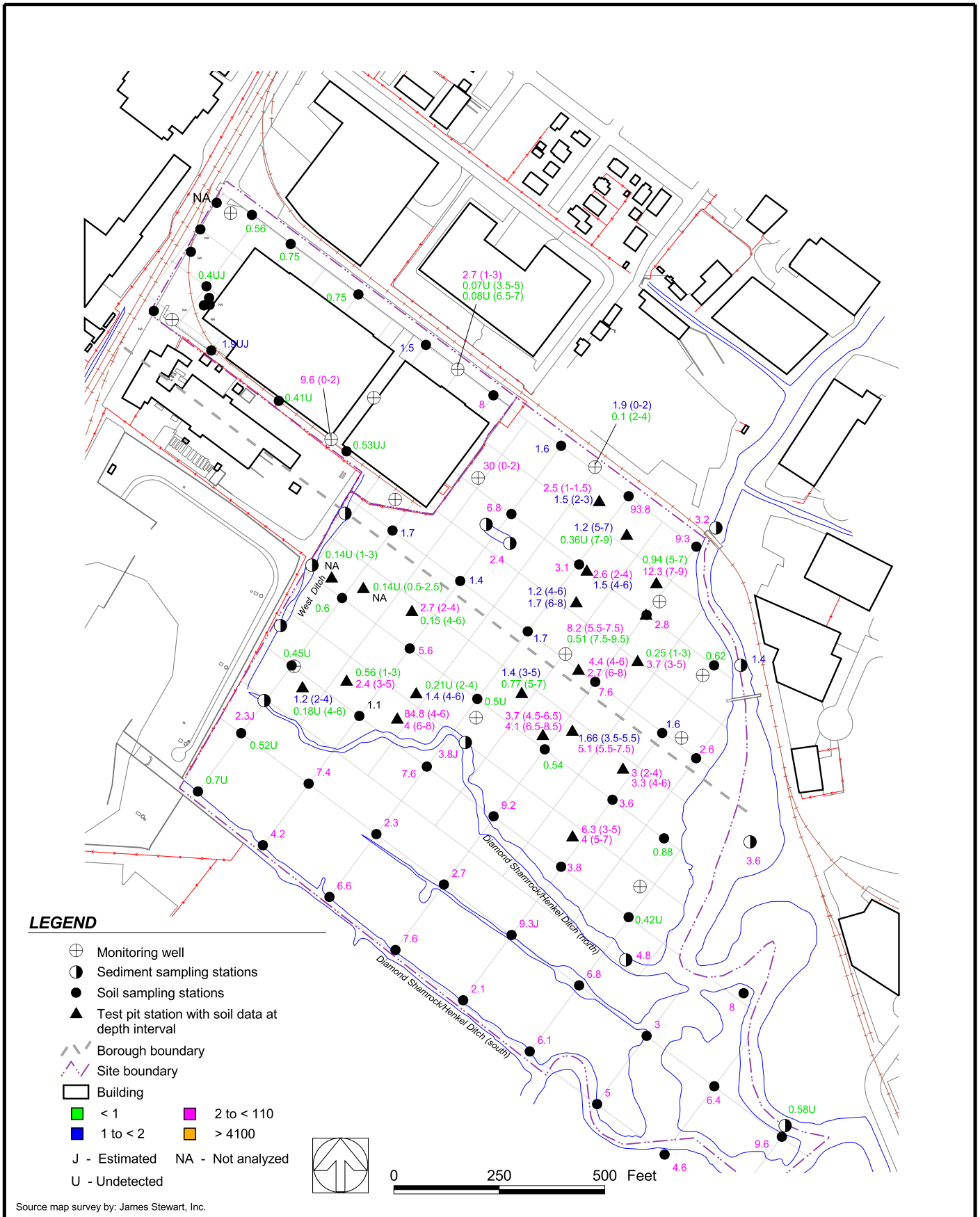
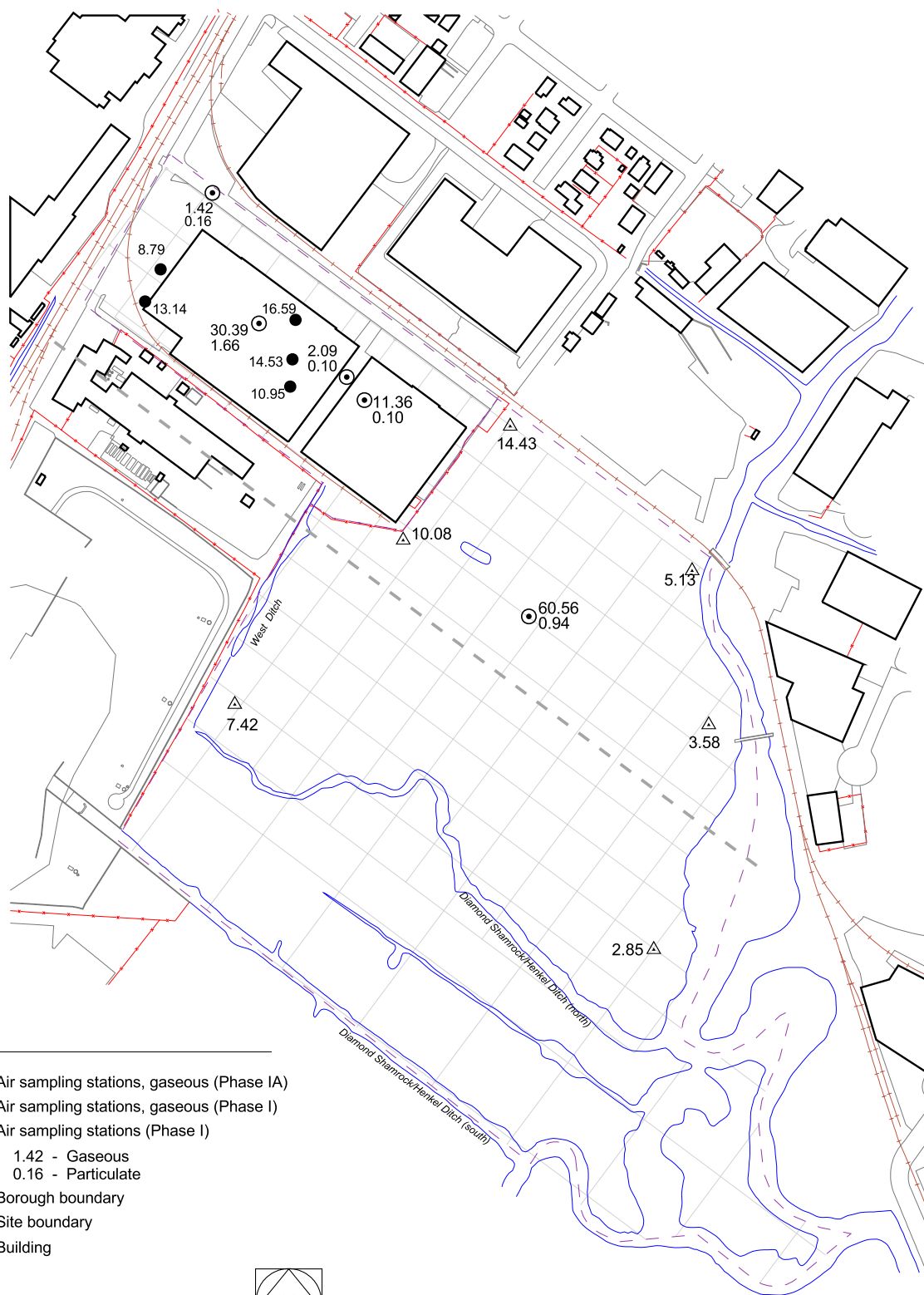
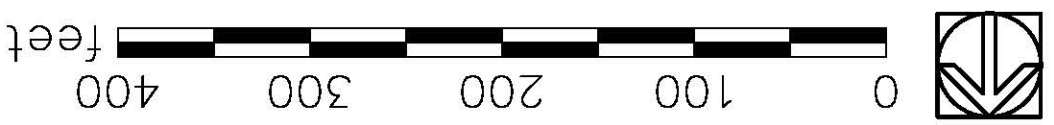


Figure 4-32. Silver concentrations (mg/kg) in surface and subsurface soils and sediments (color coding based on screening criteria values).



Source map survey by: James Stewart, Inc.

Figure 4-33. Particulate and gaseous mercury concentrations (ng/m^3) in air.



- LEGEND**
- Property line
 - Index contour (10' interval MSL)
 - Intermediate contour (2' interval MSL)
 - Borough Boundary
 - Surface water
 - Railroad
 - Fence

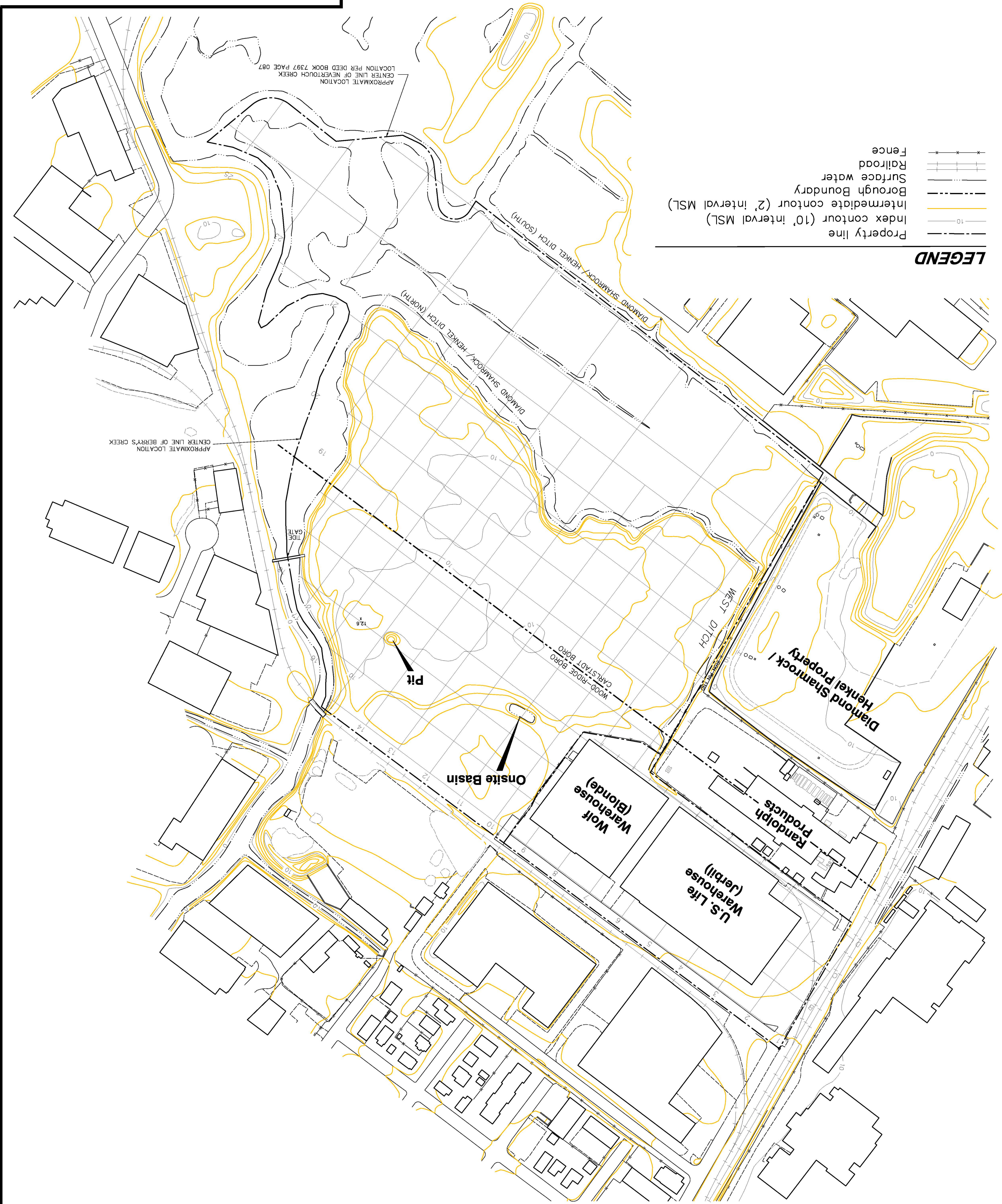


Plate 1. Topography of the Ventrone/Velsicol Site.

Table 1-1. List of SoPCs by media and operable unit

OU1 Surface Soil	OU1 Subsurface Soil	OU1 Groundwater	OU1 Seep	OU1 Surface Water	OU2 Surface Water	OU1 Sediment	OU2 Sediment	OU2 Marsh Soils
Metals								
Aluminum ^a								
Antimony	Antimony ^b	Antimony ^c						
Arsenic	Arsenic	Arsenic	Arsenic ^{b,d}		Arsenic ^e	Arsenic	Arsenic	Arsenic
Barium ^a	Barium							
	Beryllium							
Cadmium ^a	Cadmium	Cadmium ^f	Cadmium ^b			Cadmium	Cadmium	Cadmium
Chromium ^a	Chromium					Chromium	Chromium	Chromium
Cobalt ^a								
Copper	Copper ^b					Copper	Copper	Copper
Iron ^a		Iron	Iron					
Lead	Lead	Lead ^f		Lead ^e	Lead ^e	Lead	Lead	Lead
Manganese ^a		Manganese ^b						
Mercury	Mercury	Mercury	Manganese Mercury ^{b,d}	Mercury ^e	Mercury	Mercury	Mercury	Mercury
Nickel ^a	Nickel	Nickel ^b				Nickel	Nickel	Nickel
Selenium ^a	Selenium	Selenium ^{d,f}						
Silver ^a	Silver					Silver	Silver	Silver
		Sodium ^b	Sodium ^b					
Thallium	Thallium	Thallium ^f			Thallium			
Vanadium ^a	Vanadium ^a							
Zinc	Zinc					Zinc	Zinc	Zinc
Volatiles		Benzene Chlorobenzene 1,2-Dichloroethene isomers ^d Toluene ^b Xylene isomers (total)			1,1,2,2-Tetrachloroethane			
Semivolatiles						Acenaphthene Acenaphthylene Anthracene Benz[a]anthracene Benzo[a]pyrene	Acenaphthene Acenaphthylene Anthracene Benz[a]anthracene Benzo[a]pyrene	Acenaphthene Acenaphthylene Anthracene Benz[a]anthracene Benzo[a]pyrene
Benzo[a]pyrene	Benz[a]anthracene ^d Benzo[a]pyrene ^d Benzo[b]fluoranthene ^d					Benzo[g,h,i]perylene Benzo[k]fluoranthene	Benzo[g,h,i]perylene Benzo[k]fluoranthene	Benzo[g,h,i]perylene Benzo[k]fluoranthene
Bis[2-ethylhexyl]phthalate ^a		Bis[2-ethylhexyl]phthalate ^{a,b}	Bis[2-ethylhexyl]phthalate ^b		Bis[2-ethylhexyl]phthalate ^{b,d}			
	Dibenz[a,h]anthracene ^b					Chrysene Dibenz[a,h]anthracene Fluoranthene Fluorene Indeno[1,2,3-cd]pyrene	Chrysene Dibenz[a,h]anthracene Fluoranthene Fluorene Indeno[1,2,3-cd]pyrene	Chrysene Dibenz[a,h]anthracene Fluoranthene Fluorene Indeno[1,2,3-cd]pyrene
						2-Methylnaphthalene Naphthalene Phenanthrene Pyrene	2-Methylnaphthalene Naphthalene Phenanthrene Pyrene	2-Methylnaphthalene Naphthalene Phenanthrene Pyrene
PCBs						Aroclor® 1248 Aroclor® 1260	Aroclor® 1248 Aroclor® 1260	

^a Exceedances for ecological screening only

^d Exceedances for SWQS only

^b Exceedances in Phase I samples only

^e Exceedances in unfiltered samples only

^c Exceedances in NJDEP samples only

^f Exceedances in Phase IA samples only

Table 2-1. Summary of chemical analyses for Phase I samples

Component of Field Investigation	Analytes	Method Reference ^a	Number of Sample Locations (breakdown by area of Site)	QA/QC Samples
Onsite Surface Soil	TCL VOCs	EPA CLP SOW OLM03.1	52	3 duplicates
	TCL SVOCs	EPA CLP SOW OLM03.1	(9 developed area, 24 filled area, 19 marsh area)	9 rinsate blanks
	TAL metals	EPA CLP SOW ILM04.0		1 trip blank
	Methylmercury	Bloom (1989) and Liang (1994)	28 (9 filled area, 19 marsh area)	2 duplicates 2 rinsate blanks
Offsite Surface Soil	Select TCL SVOCs: benz(a)anthracene, dibenz(a,h)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, bis(2-ethylhexyl)phthalate Select TAL metals: Antimony, cadmium, copper, lead, total mercury, thallium, zinc	EPA CLP SOW OLM03.1 EPA CLP SOW ILM04.0	22	2 duplicates 2 rinsate blanks
Subsurface Soil	TCL VOCs	EPA CLP SOW OLM03.1	38	2 duplicates
	TCL SVOCs	EPA CLP SOW OLM03.1	(20 test pits in filled area)	3 rinsate blanks
	TAL metals	EPA CLP SOW ILM04.0		
	Methylmercury	Bloom (1989) and Liang (1994)	7	1 rinsate blank
Discretionary Samples from Test Pits	TAL metals Sulfate	EPA CLP SOW ILM04.0 EPA 375.4	9	None

Table 2-1. (cont.)

Component of Field Investigation	Analytes	Method Reference ^a	Number of Sample Locations (breakdown by area of Site)	QA/QC Samples
Groundwater	TCL VOCs	EPA CLP SOW OLM03.1	12	1 duplicate
	TCL SVOCs	EPA CLP SOW OLM03.1	(4 developed area, 8 filled area)	6 rinsate blanks
	TAL metals	EPA CLP SOW ILM04.0		4 trip blanks
	Methyl mercury	Bloom (1989) and Liang (1994)		
	TPH	EPA Method 418.1M		
	TDS	EPA Method 160.1		
	Chloride	EPA 325.3		
	Sulfate	EPA 375.4		
	Alkalinity	EPA 310.1		
	Orthophosphate	EPA 365.1		
	BOD	EPA 405.1		
	COD	EPA 410.4		
Seeps	TCL VOCs	EPA CLP SOW OLM03.1	5	1 duplicate
	TCL SVOCs	EPA CLP SOW OLM03.1	(3 from Berry's Creek bank, 2 from ditch banks)	2 rinsate blanks
	TAL metals	EPA CLP SOW ILM04.0		2 trip blanks
	TAL metals (filtered)	EPA CLP SOW ILM04.0		
	Methylmercury	Bloom (1989) and Liang (1994)		
	Methylmercury (filtered)	Bloom (1989) and Liang (1994)		
	TPH	EPA Method 418.1M		
	TDS	EPA Method 160.1		
Surface Water	TCL VOCs	EPA CLP SOW OLM03.1	17	1 duplicate
	TCL SVOCs	EPA CLP SOW OLM03.1	(12 from Berry's Creek: 4 locations during three tidal periods; 3 from ditch; 2 from pond)	2 rinsate blanks
	TAL metals	EPA CLP SOW ILM04.0		1 trip blank
	TAL metals (filtered)	EPA CLP SOW ILM04.0		
	Methylmercury	Bloom (1989) and Liang (1994)		
	Methylmercury (filtered)	Bloom (1989) and Liang (1994)		
	TPH	EPA Method 418.1M		
	TDS	EPA Method 160.1		
	Hardness	EPA Method 130.2		

Table 2-1. (cont.)

Component of Field Investigation	Analytes	Method Reference ^a	Number of Sample Locations (breakdown by area of Site)	QA/QC Samples
Sediment	TCL VOCs	EPA CLP SOW OLM03.1	9	1 duplicate
	TCL SVOCs	EPA CLP SOW OLM03.1	(4 from Berry's Creek; 3 from ditch; 2 from pond)	1 rinsate blank
	TCL PCBs	SW-846 Method 8080A		
	TAL metals	EPA CLP SOW ILM04.0		
	Methylmercury	Bloom (1989) and Liang (1994)		
	TPH	EPA Method 418.1M		
	TOC	SW-846 Method 9060		
	Grain Size	ASTM D422		
Air	Mercury vapor	Bloom et al. 1994	1 st round: 5	3 trip blanks
	Mercury particulates	Bloom and Fitzgerald 1998	(4 developed area, 1 filled area)	
			2 nd round: 6 (6 filled area)	1 trip blank
Hazardous Substance Inventory -Drummed Waste -Surface Samples	TCLP VOCs ^b	SW-846 Method 8260A	10 total:	1 rinsate blank
	TCLP SVOCs ^b	SW-846 Method 8270B	3 drums from test pits analyzed for full characterization	1 trip blank
	TCLP PCBs ^b	SW-846 Method 8081		
	Organochlorine pesticides	SW-846 Method 8081	3 surface drums analyzed for TAL metals only	
	Chlorinated herbicides	SW-846 Method 8150B		
	Phenols	SW-846 Method 9065	4 surface samples analyzed for TAL metals only	
	TCLP metals ^b	SW-846 Methods 6010A /7000-series		
	Free liquids	Visual inspection		
	Specific gravity	Volume and weight measurements		
	pH	SW-846 Method 9040A		
	Cyanide	SW-846 Method 9010A/9012		
	Sulfide	SW-846 Method 9030A		
	Reactivity (as reactive cyanide and sulfide)	SW-846, Chapter 7		
	Corrosivity	SW-846 Method 1110		
	Ignitability	SW-846 Method 1010 or 1020		

Note: TCL - target compound list VOC - volatile organic compound SVOC - semivolatile organic compound
TAL - target analyte list CLP - Contract Laboratory Program SOW - statement of work
OLM - organic laboratory method ILM - inorganic laboratory method TPH - total petroleum hydrocarbons
TDS - total dissolved solids BOD - biological oxygen demand COD - chemical oxygen demand
PCB - polychlorinated biphenyl EPA - U.S. Environmental Protection Agency
ASTM - American Society for Testing and Materials TCLP - toxicity characteristic leaching procedure

^a Complete method references are included in Section 9.

^b For the analysis of TCLP VOCs, SVOCs, and metals, results for TCL VOCs, SVOCs, and metals are also reported.

Table 2-2. Summary of chemical analyses for Phase IA samples

Component of Field Investigation	Analytes	Method Reference	Number of Sample Locations	QA/QC Samples
Soil				
Borehole soil	Target Metals ^a	SW-846 Method 6010B	12	1 duplicate
	Target VOCs ^b	SW-846 Method 8260	(multiple depth intervals from 3 well locations)	1 rinsate blank 1 trip blank
Off-site soil	Mercury	SW-846 Method 7471	9 (2 depth intervals from 4 locations; 2-4 ft. interval was archived and not analyzed)	1 duplicate 1 rinsate blank
Water Sampling				
Groundwater	Mercury (unfiltered)	SW-846 Method 6010B and EPA 1631	18	2 duplicates
	Mercury (filtered)	EPA 1631	3	5 rinsate blanks
	Target Metals ^a	SW-846 Method 6010B	15	4 trip blanks
	Methylmercury	Bloom (1989) and Liang (1994)		
	Target VOCs ^b	SW-846 Method 8260		
	SVOCs	SW-846 Method 8270		
	BOD	EPA 405.1		
	COD	EPA 410.4		
	Alkalinity	EPA 310.1		
	Total Chloride	EPA 300.0		
	Phosphorous	EPA 365.2		
	Sulfate	EPA 300.0		
	Sulfide	SW-846 Method 9030B		
	Nitrate	EPA 300.0		
	Ammonia	EPA 350.1		
	TDS	EPA 160.1		
	DOC	SW-846 Method 9060F		
	TPH	EPA 418.1M		
Surface Water	Target Metals ^a	SW-846 Method 6010B	3	1 duplicate
	Methylmercury	Bloom (1989) and Liang (1994)	(unfiltered)	1 rinsate blank

Table 2-2. (cont.)

Component of Field Investigation	Analytes	Method Reference	Number of Sample Locations	QA/QC Samples
Water Sampling (cont.)				
Seeps	Target Metals ^a Methylmercury	SW-846 Method 6010B Bloom (1989) and Liang (1994)	5 (field-filtered and unfiltered)	1 duplicate 1 rinsate blank
Sediment				
Surface Sediment	Target Metals ^a Methylmercury PAHs	SW-846 Method 6010B Bloom (1989) and Liang (1994) SW-846 Method 8270C	3	1 duplicate 1 rinsate blank

Note:

BOD	- biological oxygen demand
COD	- chemical oxygen demand
DOC	- dissolved organic carbon
EPA	- U.S. Environmental Protection Agency
SVOCs	- semi-volatile organic compounds
TDS	- total dissolved solids
TPH	- total petroleum hydrocarbons
VOCs	- volatile organic compounds

^a Target Metals include arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, nickel, selenium, silver, thallium, and zinc

^b Target VOCs include benzene, chlorobenzene, toluene, and xylene.

Table 3-1. Summary of groundwater elevation measurements

Monitoring Well	Ground Elevation	Elevation of Measuring Point	October 15, 1997		December 9, 1997		January 15, 1998	
			Depth to Water	Groundwater Elevation	Depth to Water	Groundwater Elevation	Depth to Water	Groundwater Elevation
MW-1	8.68	11.36	8.89	2.47	8.51	2.85	7.90	3.46
MW-1A	NA	9.15	6.53	2.62	6.44	2.71	NA	NA
MW-2	10.30	12.94	10.62	2.32	10.02	2.92	9.49	3.45
MW-3	9.55	12.32	9.84	2.48	9.32	3.00	8.81	3.51
MW-4	7.90	9.89	NA	NA	7.22	2.67	6.82	3.07
MW-4A	NA	11.55	8.72	2.83	9.09	2.46	NA	NA
MW-5	8.86	10.70	9.18	1.52	8.50	2.20	8.09	2.61
MW-6	9.57	12.12	11.98	0.14	11.34	0.78	10.88	1.24
MW-7	5.35	7.19	5.65	1.54	4.45	2.74	3.85	3.34
MW-8	5.36	8.10	6.68	1.42	5.88	2.22	5.37	2.73
MW-9	4.02	6.60	6.26	0.34	5.08	1.52	4.24	2.36
MW-10	6.76	6.52	2.30	4.22	0.84	5.68	1.14	5.38
MW-11	5.06	4.83	1.62	3.21	1.70	3.13	0.36	4.47
MW-12	5.80	7.73	5.44	2.29	5.42	2.31	4.87	2.86
MW-13	4.46	4.07						
MW-14	5.64	7.45						
MW-15	4.20	4.58						
Upstream ^a		9.13	NA	NA	10.60	- 1.47	10.77	- 1.64
Downstream ^b		9.13	NA	NA	7.58	1.55	7.56	1.57

Table 3-1. (cont.)

Monitoring Well	Ground Elevation	Elevation of Measuring Point	December 10, 1999		February 10, 2000		April 10, 2000	
			Depth to Water ^c	Groundwater Elevation	Depth to Water	Groundwater Elevation	Depth to Water	Groundwater Elevation
MW-1	8.68	11.36	8.18	3.18	8.41	2.95	8.23	3.13
MW-1A								
MW-2	10.30	12.94	9.74	3.20	9.96	2.98	9.61	3.33
MW-3	9.55	12.32	9.02	3.30	9.29	3.03	8.90	3.42
MW-4	7.90	9.89	6.92	2.97	7.26	2.63	7.04	2.85
MW-4A								
MW-5	8.86	10.70	8.25	2.45	8.45	2.25	8.28	2.42
MW-6	9.57	12.12	11.07	1.05	11.20	0.92	10.98	1.14
MW-7	5.35	7.19	3.66	3.53	4.16	3.03	4.02	3.17
MW-8	5.36	8.10	5.20	2.90	5.38	2.72	5.40	2.70
MW-9	4.02	6.60	3.69	2.91	3.60	3.00	3.39	3.21
MW-10	6.76	6.52	0.44	6.08	0.96	5.56	0.12	6.40
MW-11	5.06	4.83	0.20	4.63	NA	NA	1.14	3.69
MW-12	5.80	7.73	4.65	3.08	5.19	2.54	5.16	2.57
MW-13	4.46	4.07	1.64	2.43	2.15	1.92	2.05	2.02
MW-14	5.64	7.45	5.30	2.15	5.56	1.89	5.33	2.12
MW-15	4.20	4.58	2.05	2.53	2.29	2.29	2.36	2.22
Upstream ^a								
Downstream ^b								

Table 3-1. (cont.)

Monitoring Well	Ground Elevation	Elevation of Measuring Point	June 19, 2000		September 24, 2002	
			Depth to Water	Groundwater Elevation	Depth to Water	Groundwater Elevation
MW-1	8.68	11.36	8.23	3.13	8.95	2.41
MW-1A						
MW-2	10.30	12.94	9.72	3.22	10.54	2.40
MW-3	9.55	12.32	8.94	3.38	9.93	2.39
MW-4	7.90	9.89	6.95	2.94	7.43	2.46
MW-4A						
MW-5	8.86	10.70	8.22	2.48	8.89	1.81
MW-6	9.57	12.12	10.95	1.17	11.36	0.76
MW-7	5.35	7.19	3.90	3.29	5.31	1.88
MW-8	5.36	8.10	5.96	2.14	6.39	1.71
MW-9	4.02	6.60	3.45	3.15	5.05	1.55
MW-10	6.76	6.52	0.91	5.61	1.76	4.76
MW-11	5.06	4.83	0.15	4.68	0.70	4.13
MW-12	5.80	7.73	5.04	2.69	5.58	2.15
MW-13	4.46	4.07	1.84	2.23	2.90	1.17
MW-14	5.64	7.45	5.45	2.00	6.15	1.30
MW-15	4.20	4.58	2.11	2.47	2.90	1.68
Upstream ^a						
Downstream ^b						

Note: All elevations in feet above mean sea level
Depth to water measurements in feet
MW-15 was converted to a flush mount type completion on 12/10/99
MW-11 was saturated with snow melt water on 2/10/00
NA - not accessible for measurement

^a Surface water measuring point upstream of tide gate on Berry's Creek.

^b Surface water measuring point downstream of tide gate on Berry's Creek.

^c Post-sampling measurements.

Table 3-2. Rising-head slug test results

Monitoring Well	Hydraulic Conductivity from Test No. 1 (ft/min)	Hydraulic Conductivity from Test No. 2 (ft/min)	Average (ft/min)
MW-1	0.036	0.044	0.04
MW-2	0.0032	0.0033	0.0033
MW-3	0.027	0.028	0.028
MW-4	0.056	0.075	0.066
MW-5	0.0049	0.0048	0.0049
MW-6	0.00016	not measured ^a	0.00016
MW-7	0.0012	0.0016	0.0014
MW-8	0.0099	0.0083	0.0091
MW-9	0.0017	0.0018	0.0018
MW-10	0.005	0.0051	0.0051
MW-11	0.0041	0.0033	0.0037
MW-12	0.0034	0.0033	0.0034

^a See discussion in text

Table 3-3. Plant species observed at the Ventron/Velsicol site

Common name	Scientific Name
Arrow arum	<i>Peltandra virginica</i>
Arrow-wood	<i>Viburnum dentatum</i>
Bittersweet	<i>Celastrus</i> sp.
Black gum	<i>Nyssa sylvatica</i>
Black locust	<i>Robinia pseudo-acacia</i>
Black willow	<i>Salix nigra</i>
Catbrier	<i>Smilax glauca</i>
Choke cherry	<i>Prunus virginiana</i>
Cleavers	<i>Galium aparine</i>
Common elderberry	<i>Sambucks canadensis</i>
Common reed	<i>Phramites australis</i>
Dwarf sumac	<i>Rhus copallinum</i>
Eastern cottonwood	<i>Populus deltoides</i>
Eastern red cedar	<i>Juniperus virginiana</i>
Elm	<i>Ulmus</i> sp.
Fox grape	<i>Vitus labrusca</i>
Garlic mustard	<i>Brassica</i> sp.
Goldenrod	<i>Solidago canadensis</i>
Gray birch	<i>Betula populifolia</i>
Groundsel-tree	<i>Baccharis halimifloia</i>
Iris	<i>Iris</i> sp.
Japanese honeysuckle	<i>Lonicera japonica</i>
Japanese knotweed	<i>Polygonum cuspidatum</i>
Jewel weed	<i>Impatiens capensis</i>
Mugwort	<i>Artemisia vulgaris</i>
Mulberry	<i>Morus</i> sp.
Multiflora rose	<i>Rosa multiflora</i>
Pennsylvania smartweed	<i>Polygonum pensylvanicum</i>
Pickrel-weed	<i>Pontederia cordata</i>
Pin oak	<i>Quercus palustris</i>
Poison ivy	<i>Toxicodendron radicans</i>
Poplar	<i>Populus tremuloides</i>
Princess tree	<i>Paulownia tomentosa</i>
Red maple	<i>Acer rubrum</i>
Russian olive	<i>Elaeagnus angustifolia</i>
Sassafras	<i>Sassafras albidum</i>
Sensitive fern	<i>Ononclea sensibilis</i>
Silver maple	<i>Acer saccharinum</i>
Smooth cordgrass	<i>Spartina alterniflora</i>
Sweet gum	<i>Liquidambar styraciflua</i>
Tree-of-heaven	<i>Ailanthus altissima</i>

Note: Table based on information in Shisler (1997) and from field observations in Fall 1997 and Spring 1998.

Table 3-4. Wildlife species observed at the Ventron/Velsicol site

Common name	Scientific Name
Birds	
American crow	<i>Corvus brachyrhynchos</i>
American robin	<i>Turdus migratorius</i>
Blue jay	<i>Cyanocitta cristata</i>
Canada goose	<i>Branta canadensis</i>
Catbird	<i>Dumetella carolinensis</i>
Common flicker	<i>Colaptes auratus</i>
Common grackle	<i>Quiscalus quiscula</i>
Eastern kingbird	<i>Tyrannus tyrannus</i>
English sparrow	<i>Passer domesticus</i>
European starling	<i>Sturnus vulgaris</i>
Mallard duck	<i>Anas platyrhynchos</i>
Mockingbird	<i>Mimus polyglottos</i>
Mourning dove	<i>Zenaidura macroura</i>
Northern cardinal	<i>Picoides villosus</i>
Red-headed woodpecker	<i>Melanerpes erythrocephalus</i>
Red-winged blackbird	<i>Agelaius phoeniceus</i>
Spotted sandpiper	<i>Actitis macularia</i>
Tree swallow	<i>Iridoprocne bicolor</i>
Warbler	<i>Dendroica</i> spp.
Mammals	
Cat	<i>Felis domesticus</i>
Cottontail rabbit	<i>Sylvilagus</i> spp.
Eastern chipmunk	<i>Tamias striatus</i>
Eastern gray squirrel	<i>Sciurus carolinensis</i>
Muskrat	<i>Ondatra zibethicus</i>
Norway rat	<i>Rattus norvegicus</i>
Opossum	<i>Didelphis virginiana</i>
Wood chuck	<i>Marmota monax</i>
Herptiles	
Snapping turtle	<i>Chelydra serpentina</i>

Note: Table based on information field observations in Spring 1997, Fall 1997, and Spring 1998.

Table 3-5. Feeding habits of birds observed at the Ventron/Velsicol site

Common name	Bird % Diet of Plants by Season ^a				Site-specific Resource Attributes for Plants ^b		
	Winter	Spring	Summer	Fall	Plant Species	Site-specific abundance	Value (% of bird diet)
Common grackle	84%	52%	45%	82%	oak	low	5–10%
Tree swallow	30%	1%	21%	29%	red cedar	low	2–5%
Blue jay	91%	68%	54%	77%	oak	low	25–50%
English sparrow	99%	91%	94%	98%	knotweed	low-medium	2–5%
Red-winged blackbird	95%	60%	50%	91%	smartweed	low	5–10%
Starling	68%	7%	41%	39%	cherry	low	5–10%
American robin	64%	21%	60%	81%	cherry	low	10–25%
					sumac	low	5–10%
					black gum	low	5–10%
					grape	low	2–5%
					red cedar	low	2–5%
					sumac	low	5–10%
					elderberry	low	2–5%
					poison ivy	low	2–5%
					mulberry	low	2–5%
Mockingbird ^c	59%	17%	35%	67%	red cedar	low	2–5%
					grape	low	2–5%
					elderberry	low	2–5%
					sumac	low	2–5%
					mulberry	low	2–5%
Catbird	76%	20%	60%	81%	cherry	low	5–10%
					elderberry	low	2–5%
					grape	low	2–5%
					sumac	low	2–5%
					sassafras	low	2–5%
Warbler ^d	17%	<1%	0%	63%	red cedar	low	2–5%
					poison ivy	low	2–5%
Common flicker	63%	8%	23%	55%	poison ivy	low	10–25%
					cherry	low	2–5%
Kingbird	0%	2%	18%	36%	sassafras	low	2–5%
					cherry	low	2–5%
Red-headed woodpecker	91%	34%	37%	72%	oak	low	10–25%
					cherry	low	2–5%
					mulberry	low	2–5%
Mourning doves	99%	99%	99%	99%	knotweed	low-medium	2–5%

^a Percent diet plant values are based on stomach analysis studies cited in Martin et al., 1961.

^b Site-specific attributes are related to field observations of vegetative resources (e.g., vegetation type and abundance at the site (e.g., low, medium, high). Resource value is shown as a function of % use in the bird's diet (Martin et al. 1961).

^c Data related to diet are specific to southeastern mockingbirds.

^d Data related to diet are specific to the *Myrtle* genus of warblers.

Table 3-6. Feeding habits of mammals observed at the Ventron/Velsicol site

Common name	Bird % Diet of Plants by Season ^a				Site-specific Resource Attributes for Plants ^b		
	Winter	Spring	Summer	Fall	Plant Species	Site-specific abundance	Value (% of bird diet)
Wood chuck	100%	100%	100%	100%	herbaceous plants	high	NA
Opossum	17%	5%	13%	17%	grape	low	2–5%
Cottontail rabbit	100%	100%	100%	100%	herbaceous plants	high	NA
Eastern chipmunk	97%	69%	87%	91%	maple	low	5–10%
					oak	low	5–10%
					cherry	low	2–5%
Eastern gray squirrel	98%	100%	87%	98%	oak	low	25–50%
					maple	low	5–10%
					mulberry	low	2–5%
Muskrat ^c	98%	98%	98%	98%	cattail	low	25–50%
					common reed	high	NA
					pondweed	low	2–5%
					arrowhead	low	2–5%

Note: NA - Not available

^a Percent (%) diet plant values are based on stomach analysis studies cited in Martin et al. 1961.

^b Site-specific attributes are related to field observations of vegetative resources (e.g., vegetation type and abundance) at the site (e.g., low, medium, high). Resource value is a function of % use in the mammal's diet (Martin et al. 1961).

^c Although muskrats eat primarily vegetation, a trace amount of their diets may include aquatic invertebrates.

Table 3-7. Wetland functional assessment attributes for Ventron/Velsicol Site, best professional judgment method

Category	Rating	Rationale
Wildlife Habitat Attributes		
Aquatic Diversity and Abundance	2.0	The dense stand of <i>Phragmites</i> limits the abundance of aquatic species that use the Site. The dense <i>Phragmites</i> extends to the water's edge and does not provide space for other vegetation to colonize. The lack of emergent and submerged aquatic species along the Diamond Shamrock/Henkel ditches limits wildlife habitats and access to the Site.
General Fish Habitat	2.0	Rationale: Fish habitats on the site have a low diversity as a result of the dense <i>Phragmites</i> stands. Fish habitat is limited to Berry's Creek and the two Diamond Shamrock/Henkel ditches. The wetland surface is accessible to fish only during spring tides and storm events.
General Waterfowl Habitat	2.0	The dense growth of <i>Phragmites</i> inhibits waterfowl use of the wetlands for nesting or resting. Waterfowl use of Berry's Creek and the Diamond Shamrock/Henkel ditches is limited to a few resident and migratory species.
General Wildlife Habitat	2.0	The <i>Phragmites</i> -dominated community does not provide a diverse wildlife habitat. Berry's Creek and the Diamond Shamrock/Henkel ditches in the marsh area provide water-based wildlife habitat. These open-water systems do not support emergent or submergent vegetation communities that are the preferred habitats for most water-dependent bird species. The wetland area may be used by a few passerine species and perhaps one or two mammal species.
Production Export	3.0	The dense vegetation will be exported from the Site, but the diversity is low as a result of the dominance of <i>Phragmites</i> in the marsh area. The exported material could be used in the Berry's Creek and Hackensack River Watershed.
Overall Wildlife Habitat	2.2	The dense monoculture of <i>Phragmites</i> limits the wildlife habitat on the Site, especially for waterfowl and wildlife. The low species diversity and production on the Site limit its contribution to the adjacent areas. The wetland areas are poor habitats for wildlife.

Table 3-7. (cont.)

Category	Rating	Rationale
Water Quality Improvement Attributes		
Nutrient Removal/ Transformation	4.0	The existing <i>Phragmites</i> -dominated community on the Site is only completely inundated by Berry's Creek during spring tides and storm events. The dense <i>Phragmites</i> stand acts both as a physical and chemical trapping mechanism, providing a high value during these events.
Sediment/Toxicant Retention	4.0	The elevation of the <i>Phragmites</i> -dominated community is above normal tidal inundation. The ability to retain sediment is greatest when the marsh area is inundated during spring tides and storm events.
Overall Water Quality Improvement	4.0	The dense growth of <i>Phragmites</i> will function to improve water quality during spring tides and storm events.
Social Significance Attributes		
Recreational	0.0	The area is privately owned at present, which prohibits recreational use of the Site.
Flood Flow Alteration	8.0	The wetlands absorb and retain tidal/storm overflows from Berry's Creek.
Conservation Potential	1.0	Conservation potential is very low because of limited wildlife habitat and lack of recreational use of the Site. The marsh area is surrounded by water, and industrial and commercial properties, greatly limiting Site access.
Overall Social Significance	3.0	The major functions of the wetlands are flood-flow alteration and water quality improvement. There is no real potential for recreation and/or conservation uses of the marsh area.

Note: Table generated by assembling rankings and information provided to Exponent by Dr. Joseph Shisler. Based on May 1997 field visit.

Table 4-1a. Summary of SoPCs in onsite surface soil (OU1)

								Non-Residential Direct Contact Soil Cleanup Criteria (NJAC 7:26; 5/12/99)		Ecological Criteria Screening ^c	
Analyte	Concentration units	Number of analyses	Number of undetected values	Minimum detected value	Maximum detected value	Arithmetic mean value ^a	Geometric mean value ^a	No. of exceedances ^b	Criteria Value	No. of exceedances ^b	Criteria Value
Mercury											
Mercury (total)	mg/kg	39	0	1.2	13,800	700	90	14(0)	270	39(0)	0.00051
Methylmercury	mg/kg	9	0	0.00059	0.322	0.0401	0.0052	--	--	1(0)	0.053
Metals											
Aluminum	mg/kg	33	0	3370	12,000	6,000	6,000	--	--	33(0)	50
Antimony	mg/kg	36	18	0.79	53.7	4	1.5	0(0)	340	5(0)	5
Arsenic	mg/kg	36	7	2.1	26.4	7	5	1(0)	20	7(0)	9.9
Barium	mg/kg	36	0	26.9	818	250	180	0(0)	47,000	15(0)	283
Beryllium	mg/kg	33	31	0.26	0.68	0.23	0.22	0(0)	2	0(0)	10
Cadmium	mg/kg	39	15	0.22	21.2	3	1	0(0)	100	7(0)	4
Chromium	mg/kg	36	0	6.6	1,150	90	40	--	--	36(0)	0.4
Copper	mg/kg	39	0	12.4	7,420	380	120	3(0)	600	29(0)	60
Iron	mg/kg	36	0	3,900	122,000	24,000	18,000	--	--	36(0)	200
Lead	mg/kg	39	0	17.8	4,320	500	200	6(0)	600	32(0)	40.5
Manganese	mg/kg	36	0	66.3	3,090	390	270	--	--	33(0)	100
Nickel	mg/kg	36	4	4.7	87.8	33.4	24.8	0(0)	2,400	19(0)	30
Selenium	mg/kg	36	24	0.62	2	0.7	0.6	0(0)	3,100	12(23)	0.021
Silver	mg/kg	36	7	0.54	93.8	5	2	0(0)	4,100	14(0)	2
Sodium	mg/kg	33	29	592	2,580	300	200	--	--	--	--
Thallium	mg/kg	39	34	0.8	21.9	1.7	0.8	3(0)	2	4(4)	1
Vanadium	mg/kg	33	0	6	175	50	30	0(0)	7,100	33(0)	2
Zinc	mg/kg	39	6	89	25,400	1,900	600	6(0)	1,500	33(6)	8.5
Volatile Organic Compounds											
1,1,2,2-Tetrachloroethane	µg/kg	33	33	ND	ND	6	6	0(0)	70,000	--	--
Benzene	µg/kg	36	30	3.6	2,800	90	8	0(0)	13,000	0(0)	523,000
Chlorobenzene	µg/kg	36	35	1.2	1.2	6	6	0(0)	680,000	0(0)	40,000
1,2-Dichloroethene isomers (total)	µg/kg	33	33	ND	ND	6	6	0(0)	1,000,000	--	--
Toluene	µg/kg	36	33	2.2	11	6	6	0(0)	1,000,000	0(0)	200,000
Xylene isomers (total)	µg/kg	33	33	ND	ND	6	6	0(0)	1,000,000	0(0)	5,000

Table 4-1a. (cont.)

								Non-Residential Direct Contact Soil Cleanup Criteria (NJAC 7:26; 5/12/99)		Ecological Criteria Screening ^c	
Analyte	Concentration units	Number of analyses	Number of undetected values	Minimum detected value	Maximum detected value	Arithmetic mean value ^a	Geometric mean value ^a	No. of exceedances ^b	Criteria Value	No. of exceedances ^b	Criteria Value
Semivolatile Organic Compounds											
Acenaphthene	μg/kg	33	19	40	1,200	400	200	0(0)	10,000,000	--	20,000
Acenaphthylene	μg/kg	33	26	44	99	400	200	--	--	--	--
Anthracene	μg/kg	33	10	40	4,100	500	200	0(0)	10,000,000	--	--
Benz[a]anthracene	μg/kg	36	4	78	4,000	800	500	0(0)	4,000	--	--
Benzo[a]pyrene	μg/kg	36	4	73	10,000	1,000	500	11(1)	660	--	20,000
Benzo[b]fluoranthene	μg/kg	36	6	73	13,000	1,000	600	2(0)	4,000	--	--
Benzo[ghi]perylene	μg/kg	33	4	48	2,200	500	300	--	--	--	--
Benzo[k]fluoranthene	μg/kg	36	6	51	4,700	600	300	1(0)	4,000	--	--
bis[2-Ethylhexyl]phthalate	μg/kg	36	12	310	380,000	20,000	1,000	2(0)	210,000	1(0)	363,000
Chrysene	μg/kg	33	3	56	12,000	1,000	500	0(0)	40,000	--	--
Dibenz[a,h]anthracene	μg/kg	36	14	44	900	300	200	1(1)	660	--	--
Fluoranthene	μg/kg	33	2	94	26,000	2,000	800	0(0)	10,000,000	--	--
Fluorene	μg/kg	33	18	41	1,100	400	200	0(0)	10,000,000	--	--
Indeno[1,2,3-cd]pyrene	μg/kg	36	5	57	2,600	500	300	0(0)	4,000	--	--
2-Methylnaphthalene	μg/kg	33	27	60	190	400	200	--	--	--	--
Naphthalene	μg/kg	33	26	62	630	400	300	0(0)	4,200,000	--	--
Pyrene	μg/kg	33	1	42	24,000	2,000	700	0(0)	10,000,000	--	--

Notes: Analytes shown in bold are media-specific SoPCs; analytes shown in italics are not media-specific SoPCs, but have been provided to support the assessment of SoPC transport and fate.

-- - No media specific criterion

ND - None detected

^a Arithmetic and geometric means were calculated using detected values and one-half the reported instrument detection limit (IDL) for undetected values.

^b Number of criteria exceedances for detected samples is followed by the number of samples in which the substance was not detected and the detection limit is greater than the criteria value.

^c See Appendix B for ecological criteria sources and citations.

Table 4-1b. Summary of SoPCs in onsite surface soil (OU1) -- developed area only

								Non-Residential Direct Contact Soil Cleanup Criteria (NJAC 7:26; 5/12/99)		Ecological Criteria Screening ^c	
Analyte	Concentration units	Number of analyses	Number of undetected values	Minimum detected value	Maximum detected value	Arithmetic mean value ^a	Geometric mean value ^a	No. of exceedances ^b	Criteria Value	No. of exceedances ^b	Criteria Value
Mercury											
Mercury (total)	mg/kg	14	0	9.3	13,800	1,800	500	10(0)	270	14(0)	0.00051
Methylmercury	mg/kg	NA	NA	NA	NA	NA	NA	NA	--	NA	0.053
Metals											
Aluminum	mg/kg	9	0	3,370	12,000	7,000	6,000	--	--	9(0)	50
Antimony	mg/kg	12	12	0	0	1.1	0.7	0(0)	340	0	5
Arsenic	mg/kg	11	3	2.1	11	5	3	0(0)	20	1(0)	9.9
Barium	mg/kg	11	0	26.9	818	180	120	0(0)	47,000	2(0)	283
Beryllium	mg/kg	9	8	0.68	0.68	0.25	0.22	0(0)	2	0(0)	10
Cadmium	mg/kg	14	6	0.22	3.4	1	0.5	0(0)	100	0(0)	4
Chromium	mg/kg	11	0	6.6	131	34	20	--	--	11(0)	0.4
Copper	mg/kg	14	0	12.4	7,420	630	90	1(0)	600	7(0)	60
Iron	mg/kg	11	0	3,900	35,400	15,000	12,000	--	--	11(0)	200
Lead	mg/kg	14	0	17.8	390	120	80	0(0)	600	8(0)	40.5
Manganese	mg/kg	11	0	110	540	270	240	--	--	11(0)	100
Nickel	mg/kg	11	2	4.7	87.8	28.4	17.3	0(0)	2,400	4(0)	30
Selenium	mg/kg	11	9	0.69	1.1	0.4	0.4	0(0)	3,100	2(8)	0.021
Silver	mg/kg	11	4	0.56	9.6	2	1	0(0)	4,100	3(0)	2
Sodium	mg/kg	9	8	630	630	190	160	--	--	--	--
Thallium	mg/kg	14	11	0.8	5.4	1.1	0.8	1(0)	2	2(1)	1
Vanadium	mg/kg	9	0	6	140	40	20	0(0)	7,100	9(0)	2
Zinc	mg/kg	14	0	89	2,110	500	400	1(0)	1,500	14(0)	8.5
Volatile Organic Compounds											
1, 1,2,2-Tetrachloroethane	µg/kg	9	9	ND	ND	5.7	5.6	0(0)	70,000	--	--
Benzene	µg/kg	11	6	5	2,800	300	20	0(0)	13,000	0(0)	523,000
Chlorobenzene	µg/kg	11	10	1.2	1.2	5	4.6	0(0)	680,000	0(0)	40,000
1,2-Dichloroethene isomers (total)	µg/kg	9	9	ND	ND	5.7	5.6	0(0)	1,000,000	--	--
Toluene	µg/kg	11	9	3	11	6	6	0(0)	1,000,000	0(0)	200,000
Xylene isomers (total)	µg/kg	9	9	ND	ND	5.7	5.6	0(0)	1,000,000	0(0)	5,000

Table 4-1b. (cont.)

								Non-Residential Direct Contact Soil Cleanup Criteria (NJAC 7:26; 5/12/99)				Ecological Criteria Screening ^c	
								No. of exceedances ^b	Criteria Value	No. of exceedances ^b	Criteria Value		
Analyte	Concentration units	Number of analyses	Number of undetected values	Minimum detected value	Maximum detected value	Arithmetic mean value ^a	Geometric mean value ^a						
Semivolatile Organic Compounds													
Acenaphthene	μg/kg	9	3	40	230	140	110	0(0)	10,000,000	--	20,000		
Acenaphthylene	μg/kg	9	7	53	69	180	160	--	--	--	--		
Anthracene	μg/kg	9	2	40	460	170	130	0(0)	10,000,000	--	--		
Benz[a]anthracene	μg/kg	12	2	150	1,400	500	400	0(0)	4,000	--	--		
Benzo[a]pyrene	μg/kg	12	2	120	1,100	400	400	2(0)	660	--	20,000		
Benzo[b]fluoranthene	μg/kg	12	1	73	1,400	500	400	0(0)	4,000	--	--		
Benzo[ghi]perylene	μg/kg	9	2	96	520	240	210	--	--	--	--		
Benzo[k]fluoranthene	μg/kg	12	1	51	565	250	210	0(0)	4,000	--	--		
bis[2-Ethylhexyl]phthalate	μg/kg	12	1	310	10,800	2,800	1,500	0(0)	210,000	0(0)	363,000		
Chrysene	μg/kg	9	1	56	1,400	500	300	0(0)	40,000	--	--		
Dibenz[a,h]anthracene	μg/kg	12	6	50	150	120	110	0(0)	660	--	--		
Fluoranthene	μg/kg	9	0	94	2,600	800	500	0(0)	10,000,000	--	--		
Fluorene	μg/kg	9	2	41	370	160	120	0(0)	10,000,000	--	--		
Indeno[1,2,3-cd]pyrene	μg/kg	12	2	75	470	230	210	0(0)	4,000	--	--		
2-Methylnaphthalene	μg/kg	9	6	60	190	180	160	--	--	--	--		
Naphthalene	μg/kg	9	7	92	94	190	170	0(0)	4,200,000	--	--		
Pyrene	μg/kg	9	0	43	2,600	800	400	0(0)	10,000,000	--	--		

Notes: Analytes shown in bold are media-specific SoPCs; analytes shown in italics are not media-specific SoPCs, but have been provided to support the assessment of SoPC transport and fate.

-- - No media specific criterion

NA - Not analyzed

ND - None detected

^a Arithmetic and geometric means were calculated using detected values and one-half the reported instrument detection limit (IDL) for undetected values.

^b Number of criteria exceedances for detected samples is followed by the number of samples in which the substance was not detected and the detection limit is greater than the criteria value.

^c See Appendix B for ecological criteria sources and citations.

Table 4-1c. Summary of SoPCs in onsite surface soil (OU1) -- undeveloped area only

								Non-Residential Direct Contact Soil Cleanup Criteria (NJAC 7:26; 5/12/99)				Ecological Criteria Screening ^c	
Analyte	Concentration units	Number of analyses	Number of undetected values	Minimum detected value	Maximum detected value	Arithmetic mean value ^a	Geometric mean value ^a	No. of exceedances ^b	Criteria Value	No. of exceedances ^b	Criteria Value		
Mercury													
Mercury (total)	mg/kg	25	0	1.2	548	110	40	4(0)	270	25(0)	0.00051		
Methylmercury	mg/kg	9	0	0.00059	0.322	0.0401	0.0052	--	--	1(0)	0.053		
Metals													
Aluminum	mg/kg	24	0	3,580	11,000	6,000	6,000	--	--	24(0)	50		
Antimony	mg/kg	24	6	0.79	53.7	5.5	2.2	0(0)	340	5(0)	5		
Arsenic	mg/kg	25	4	4.3	26.4	7.8	6	1(0)	20	6(0)	9.9		
Barium	mg/kg	25	0	33.3	608	280	230	0(0)	47,000	13(0)	283		
Beryllium	mg/kg	24	23	0.26	0.26	0.23	0.22	0(0)	2	0(0)	10		
Cadmium	mg/kg	25	9	0.25	21.2	3.7	1.7	0(0)	100	7(0)	4		
Chromium	mg/kg	25	0	11.3	1,150	120	60	--	--	25(0)	0.4		
Copper	mg/kg	25	0	22.8	1,010	230	150	2(0)	600	22(0)	60		
Iron	mg/kg	25	0	5,530	122,000	28,000	21,000	--	--	25(0)	200		
Lead	mg/kg	25	0	39.3	4,320	800	400	6(0)	600	24(0)	40.5		
Manganese	mg/kg	25	0	66.3	3,090	440	290	--	--	22(0)	100		
Nickel	mg/kg	25	2	11.4	81.7	35.5	29	0(0)	2,400	15(0)	30		
Selenium	mg/kg	25	15	0.62	2	0.8	0.7	0(0)	3,100	10(15)	0.021		
Silver	mg/kg	25	3	0.54	93.8	6.5	2	0(0)	4,100	11(0)	2		
Sodium	mg/kg	24	21	592	2,580	400	200	--	--	--	--		
Thallium	mg/kg	25	23	14.5	21.9	2	0.8	2(0)	2	2(3)	1		
Vanadium	mg/kg	24	0	9.9	175	50	39	0(0)	7,100	24(0)	2		
Zinc	mg/kg	25	6	192	25,400	2,600	700	5(0)	1,500	19(6)	8.5		
Volatile Organic Compounds													
1,1,2,2-Tetrachloroethane	µg/kg	24	24	ND	ND	7	7	0(0)	70,000	--	--		
Benzene	µg/kg	25	24	3.6	3.6	7	6	0(0)	13,000	0(0)	523,000		
Chlorobenzene	µg/kg	25	25	0	0	7	6	0(0)	680,000	0(0)	40,000		
1,2-Dichloroethene isomers (total)	µg/kg	24	24	ND	ND	7	7	0(0)	1,000,000	--	--		
Toluene	µg/kg	25	24	2.2	2.2	6	6	0(0)	1,000,000	0(0)	200,000		
Xylene isomers (total)	µg/kg	24	24	ND	ND	7	7	0(0)	1,000,000	0(0)	5,000		

Table 4-1c. (cont.)

								Non-Residential Direct Contact Soil Cleanup Criteria (NJAC 7:26; 5/12/99)		Ecological Criteria Screening ^c	
Analyte	Concentration units	Number of analyses	Number of undetected values	Minimum detected value	Maximum detected value	Arithmetic mean value ^a	Geometric mean value ^a	No. of exceedances ^b	Criteria Value	No. of exceedances ^b	Criteria Value
Semivolatile Organic Compounds											
Acenaphthene	µg/kg	24	16	48	1,200	500	300	0(0)	10,000,000	--	20,000
Acenaphthylene	µg/kg	24	19	44	99	500	200	--	--	--	--
Anthracene	µg/kg	24	8	45	4,100	600	200	0(0)	10,000,000	--	--
Benz[a]anthracene	µg/kg	24	2	78	4,000	900	500	0(0)	4,000	--	--
Benzo[a]pyrene	µg/kg	24	2	73	10,000	1,000	600	9(1)	660	--	20,000
Benzo[b]fluoranthene	µg/kg	24	5	160	13,000	2,000	700	2(0)	4,000	--	--
Benzo[ghi]perylene	µg/kg	24	2	48	2,200	700	400	--	--	--	--
Benzo[k]fluoranthene	µg/kg	24	5	68	4,700	700	300	1(0)	4,000	--	--
bis[2-Ethylhexyl]phthalate	µg/kg	24	11	460	380,000	30,000	900	2(0)	210,000	1(0)	363,000
Chrysene	µg/kg	24	2	90	12,000	1,000	700	0(0)	40,000	--	--
Dibenz[a,h]anthracene	µg/kg	24	8	44	900	400	200	1(1)	660	--	--
Fluoranthene	µg/kg	24	2	120	26,000	2,000	900	0(0)	10,000,000	--	--
Fluorene	µg/kg	24	16	55	1,100	500	300	0(0)	10,000,000	--	--
Indeno[1,2,3-cd]pyrene	µg/kg	24	3	57	2,600	700	400	0(0)	4,000	--	--
2-Methylnaphthalene	µg/kg	24	21	69	120	500	300	--	--	--	--
Naphthalene	µg/kg	24	19	62	630	500	300	0(0)	4,200,000	--	--
Pyrene	µg/kg	24	1	42	24,000	2,000	800	0(0)	10,000,000	--	--

Notes: Analytes shown in bold are media-specific SoPCs; analytes shown in italics are not media-specific SoPCs, but have been provided to support the assessment of SoPC transport and fate.

-- - No media specific criterion

ND - None detected

^a Arithmetic and geometric means were calculated using detected values and one-half the reported instrument detection limit (IDL) for undetected values.

^b Number of criteria exceedances for detected samples is followed by the number of samples in which the substance was not detected and the detection limit is greater than the criteria value.

^c See Appendix B for ecological criteria sources and citations.

Table 4-2a. Summary of SoPCs in subsurface soil (OU1, test pits, and boreholes)

Analyte	Concentration Units	Number of Analyses	Number of Undetected Values	Minimum Detected Value	Maximum Detected Value	Arithmetic Mean Value ^a	Geometric Mean Value ^a	U.S. EPA (1996). Soil Screening Guidance: Technical Background Document		Impact to Groundwater Soil Cleanup Criteria (NJAC 7:26; 5/12/99)		Non-Residential Direct Contact Soil Cleanup Criteria (NJAC 7:26; 5/12/99)	
								No. of Exceedances ^b	Criteria Values ^c	No. of Exceedances ^b	Criteria Values	No. of Exceedances ^b	Criteria Values
Mercury													
Mercury	mg/kg	50	0	0.1942	34,700	1,100	40	50 (0)	0.1	--	--	9 (0)	270
<i>Methylmercury</i>	mg/kg	7	0	0.0001	0.00744	0.00294	0.00128	--	--	--	--	--	--
Metals													
Antimony	mg/kg	40	7	0.36	41.2	6.5	2.8	33 (1)	0.3	--	--	0 (0)	340
Arsenic	mg/kg	45	1	1.4	120	14	9	44 (0)	1	--	--	7 (0)	20
Barium	mg/kg	45	0	29.5	1,290	490	330	38 (0)	82	--	--	0 (0)	47,000
Beryllium	mg/kg	40	38	1.1	2	0.37	0.32	0 (0)	3	--	--	1 (0)	2
Cadmium	mg/kg	45	0	0.4	36.1	6	3	43 (0)	0.4	--	--	0 (0)	100
Chromium	mg/kg	45	0	6.4	606	106	58	45 (0)	2	--	--	--	--
Copper	mg/kg	45	0	6.7	2,190	290	160	--	--	--	--	3 (0)	600
<i>Iron</i>	mg/kg	45	0	1,840	293,000	41,000	29,000	--	--	--	--	--	--
Lead	mg/kg	45	0	5	3,830	1,050	390	30 (0)	400	--	--	26 (0)	600
<i>Manganese</i>	mg/kg	45	0	16.5	23,300	900	300	--	--	--	--	--	--
Nickel	mg/kg	45	0	8.2	317	61	42	45 (0)	7	--	--	0 (0)	2,400
Selenium	mg/kg	45	29	0.84	6.4	1.3	0.9	16 (26)	0.3	--	--	0 (0)	3,100
Silver	mg/kg	45	9	0.16	84.8	4.1	1.1	19 (0)	2	--	--	0 (0)	4,100
<i>Sodium</i>	mg/kg	40	18	63	2,780	250	100	--	--	--	--	--	--
Thallium	mg/kg	45	41	1.3	12.9	1.4	0.7	4 (41)	0.04	--	--	3 (1)	2
Vanadium	mg/kg	40	0	7.4	980	72	42	2 (0)	300	--	--	0 (0)	7,100
Zinc	mg/kg	45	0	26.8	43,200	2,200	800	34 (0)	620	--	--	14 (0)	1,500
Volatile Organic Compounds													
<i>Benzene</i>	μg/kg	45	38	1.5	330	20	8	NS	2	0 (0)	1,000	0 (0)	13,000
<i>Chlorobenzene</i>	μg/kg	45	44	10	10	6.7	6.4	NS	70	0 (0)	1,000	0 (0)	680,000
<i>1,2-Dichloroethene isomers</i>	μg/kg	40	40			7.2	7.1	--	--	0 (0)	1,000	0 (0)	1,000,000
<i>Toluene</i>	μg/kg	45	40	2	70,000	2,100	10	NS	600	0 (0)	500,000	0 (0)	1,000,000
<i>Xylene isomers (total)</i>	μg/kg	40	37	97	110,000	3,000	10	--	--	1 (0)	67,000	0 (0)	1,000,000
Semivolatile Organic Compounds													
Benz[a]anthracene	μg/kg	40	10	55	62,000	2,100	400	NS	80	0 (0)	500,000	2 (0)	4,000
Benzo[a]pyrene	μg/kg	40	12	72	52,000	1,800	400	NS	400	0 (0)	100,000	10 (0)	660
Benzo[b]fluoranthene	μg/kg	40	10	74	64,000	2,400	500	NS	200	1 (0)	50,000	2 (0)	4,000
<i>bis[2-Ethylhexyl]phthalate</i>	μg/kg	40	7	86	22,000	1,900	600	NS	180,000	0 (0)	100,000	0 (0)	210,000
Dibenz[a,h]anthracene	μg/kg	40	19	53	1,300	210	160	NS	80	0 (0)	100,000	1 (0)	660

Note: Analytes shown in bold are media-specific SoPCs; analytes shown in italics are not media-specific SoPCs, but have been provided to support the assessment of SoPC transport and fate.

Table reflects results of compliance averaging (see Table B3-2).

-- - No media specific criterion

NS - Not screened

SoPC - Substance of potential concern

^a Arithmetic and geometric means were calculated using detected values and one-half the reported instrument detection limit for undetected values.

^b Number of criteria exceedances for detected samples is followed by the number of samples in which the substance was not detected and the detection limit is greater than the criteria value.

^c Soil screening level for migration to groundwater with a dilution attenuation factor of 1.

Table 4-2b. Summary of SoPCs in subsurface soil (OU1, test pits)

Analyte	Concentration Units	Number of Analyses	Number of Undetected Values	Minimum Detected Value	Maximum Detected Value	Arithmetic Mean Value ^a	Geometric Mean Value ^a	U.S. EPA (1996). Soil Screening Guidance: Technical Background Document		Impact to Groundwater Soil Cleanup Criteria (NJAC 7:26; 5/12/99)		Non-Residential Direct Contact Soil Cleanup Criteria (NJAC 7:26; 5/12/99)	
								No. of Exceedances ^b	Criteria Values	No. of Exceedances ^b	Criteria Values ^c	No. of Exceedances ^b	Criteria Values
Mercury													
Mercury	mg/kg	40	0	0.26	34,700	1,000	30	40 (0)	0.1	--	--	5 (0)	270
<i>Methylmercury</i>	mg/kg	7	0	0.0001	0.00744	0.00294	0.0013	--	--	--	--	--	--
Metals													
Antimony	mg/kg	40	7	0.36	41.2	6.5	2.8	33 (1)	0.3	--	--	0 (0)	340
Arsenic	mg/kg	40	1	1.4	120	14	9	39 (0)	1	--	--	6 (0)	20
Barium	mg/kg	40	0	29.5	1,290	500	340	35 (0)	82	--	--	0 (0)	47,000
Beryllium	mg/kg	40	38	1.1	2	0.37	0.32	0 (0)	3	--	--	1 (0)	2
Cadmium	mg/kg	40	0	0.4	36.1	6	3.3	39 (0)	0.4	--	--	0 (0)	100
Chromium	mg/kg	40	0	6.4	606	116	65	40 (0)	2	--	--	--	--
Copper	mg/kg	40	0	6.7	2,190	310	170	--	--	--	--	3 (0)	600
<i>Iron</i>	mg/kg	40	0	1,840	293,000	41,000	29,000	--	--	--	--	--	--
Lead	mg/kg	40	0	5.9	3,830	1,120	490	28 (0)	400	--	--	25 (0)	600
<i>Manganese</i>	mg/kg	40	0	16.5	23,300	900	300	--	--	--	--	--	--
Nickel	mg/kg	40	0	8.2	317	64	45	40 (0)	7	--	--	0 (0)	2,400
Selenium	mg/kg	40	27	0.84	6.4	1.31	0.89	13 (26)	0.3	--	--	0 (0)	3,100
Silver	mg/kg	40	6	0.16	84.8	4.5	1.4	18 (0)	2	--	--	0 (0)	4,100
<i>Sodium</i>	mg/kg	40	18	63	2,780	250	100	--	--	--	--	--	--
Thallium	mg/kg	40	37	9.4	12.9	1.5	0.7	3 (37)	0.04	--	--	3 (1)	2
Vanadium	mg/kg	40	0	7.4	980	72	42	2 (0)	300	--	--	0 (0)	7,100
Zinc	mg/kg	40	0	41.5	43,200	2,400	900	33 (0)	620	--	--	14 (0)	1,500
Volatile Organic Compounds													
<i>Benzene</i>	μg/kg	40	38	8	10	7.3	7.1	NS	2	0 (0)	1,000	0 (0)	13,000
<i>Chlorobenzene</i>	μg/kg	40	39	10	10	7.2	7	NS	70	0 (0)	1,000	0 (0)	680,000
<i>1,2-Dichloroethene isomers</i>	μg/kg	40	40	ND	ND	7.2	7.1	--	--	0 (0)	1,000	0 (0)	1,000,000
<i>Toluene</i>	μg/kg	40	37	15	70,000	2,300	10	NS	600	0 (0)	500,000	0 (0)	1,000,000
<i>Xylene isomers (total)</i>	μg/kg	40	37	97	110,000	3,000	10	--	--	1 (0)	67,000	0 (0)	1,000,000
Semivolatile Organic Compounds													
Benz[a]anthracene	μg/kg	40	10	55	62,000	2,100	400	NS	80	0 (0)	500,000	2 (0)	4,000
Benzo[a]pyrene	μg/kg	40	12	72	52,000	1,800	400	NS	400	0 (0)	100,000	10 (0)	660
Benzo[b]fluoranthene	μg/kg	40	10	74	64,000	2,400	500	NS	200	1 (0)	50,000	2 (0)	4,000
<i>bis[2-Ethylhexyl]phthalate</i>	μg/kg	40	7	86	22,000	1,900	600	NS	180,000	0 (0)	100,000	0 (0)	210,000
Dibenz[a,h]anthracene	μg/kg	40	19	53	1,300	210	160	NS	80	0 (0)	100,000	1 (0)	660

Note: Analytes shown in bold are media-specific SoPCs; analytes shown in italics are not media-specific SoPCs, but have been provided to support the assessment of SoPC transport and fate.

Table reflects results of compliance averaging (see Table B3-2).

-- - No media-specific criterion

NS - Not screened

SoPC - Substance of potential concern

^a Arithmetic and geometric means were calculated using detected values and one-half the reported instrument detection limit for undetected values.

^b Number of criteria exceedances for detected samples is followed by the number of samples in which the substance was not detected and the detection limit is greater than the criteria value.

^c Soil screening level for migration to groundwater with a dilution attenuation factor of 1.

Table 4-2c. Summary of SoPCs in subsurface soil (OU1, boreholes)

Analyte	Concen- tration Units	Number of Analyses	Number of Undetected Values	Minimum Detected Value	Maximum Detected Value	Arithmetic Mean Value ^a	Geometric Mean Value ^a	U.S. EPA (1996). Soil Screening Guidance: Technical Background Document		Impact to Groundwater Soil Cleanup Criteria (NJAC 7:26; 5/12/99)		Non-Residential Direct Contact Soil Cleanup Criteria (NJAC 7:26; 5/12/99)	
								No. of Exceedances ^b	Criteria Values ^c	No. of Exceedances ^b	Criteria Values	No. of Exceedances ^b	Criteria Values
Mercury													
Mercury	mg/kg	10	0	0.1942	5,150	1,800	80	10 (0)	0.1	--	--	4 (0)	270
<i>Methylmercury</i>	mg/kg	NA	NA	NA	NA	NA	NA	--	--	--	--	--	--
Metals													
Antimony	mg/kg	NA	NA	NA	NA	NA	NA	NA	0.3	--	--	NA	340
Arsenic	mg/kg	5	0	3.8	44.1	14.4	9.4	5 (0)	1	--	--	1 (0)	20
Barium	mg/kg	5	0	59.5	922	439	261	3 (0)	82	--	--	0 (0)	47,000
Beryllium	mg/kg	NA	NA	NA	NA	NA	NA	NA	3	--	--	NA	2
Cadmium	mg/kg	5	0	0.4	9.6	3	2	4 (0)	0.4	--	--	0 (0)	100
Chromium	mg/kg	5	0	10.3	44.2	25.3	21.8	5 (0)	2	--	--	--	--
Copper	mg/kg	5	0	23.4	397	163	95	--	--	--	--	0 (0)	600
<i>Iron</i>	mg/kg	5	0	12,000	107,000	41,000	30,000	--	--	--	--	--	--
Lead	mg/kg	5	0	5	1,640	440	70	2 (0)	400	--	--	1 (0)	600
<i>Manganese</i>	mg/kg	5	0	307	812	504	469	--	--	--	--	--	--
Nickel	mg/kg	5	0	9.7	57.3	33.7	26.7	5 (0)	7	--	--	0 (0)	2,400
Selenium	mg/kg	5	2	1.1	1.8	0.9	0.7	3 (0)	0.3	--	--	0 (0)	3,100
Silver	mg/kg	5	3	1.1	4.3	1.1	0.2	1 (0)	2	--	--	0 (0)	4,100
<i>Sodium</i>	mg/kg	NA	NA	NA	NA	NA	NA	--	--	--	--	--	--
Thallium	mg/kg	5	4	1.3	1.3	0.5	0.4	1 (4)	0.04	--	--	0 (0)	2
Zinc	mg/kg	5	0	26.8	803	342	170	1 (0)	620	--	--	0 (0)	1,500
Volatile Organic Compounds													
<i>Benzene</i>	μg/kg	5	0	1.5	330	80	20	NS	2	0 (0)	1,000	0 (0)	13,000
<i>Chlorobenzene</i>	μg/kg	5	5			3.2	3.1	NS	70	0 (0)	1,000	0 (0)	680,000
<i>1,2-Dichloroethene isomers</i>	μg/kg	NA	NA	NA	NA	NA	NA	--	--	NA	1,000	NA	1,000,000
<i>Toluene</i>	μg/kg	5	3	2	6.4	3	3	NS	600	0 (0)	500,000	0 (0)	1,000,000
<i>Xylene isomers (total)</i>	μg/kg	NA	NA	NA	NA	NA	NA	--	--	1 (0)	67,000	0 (0)	1,000,000
Semivolatile Organic Compounds													
Benz[a]anthracene	μg/kg	NA	NA	NA	NA	NA	NA	NA	80	NA	500,000	NA	4,000
Benzo[a]pyrene	μg/kg	NA	NA	NA	NA	NA	NA	NA	400	NA	100,000	NA	660
Benzo[b]fluoranthene	μg/kg	NA	NA	NA	NA	NA	NA	NA	200	NA	50,000	NA	4,000
<i>bis[2-Ethylhexyl]phthalate</i>	μg/kg	NA	NA	NA	NA	NA	NA	NA	180,000	NA	100,000	NA	210,000
Dibenz[a,h]anthracene	μg/kg	NA	NA	NA	NA	NA	NA	NA	80	NA	100,000	NA	660

Note: Analytes shown in bold are media-specific SoPCs; analytes shown in italics are not media-specific SoPCs, but have been provided to support the assessment of SoPC transport and fate.

Table reflects results of compliance averaging (see Table B3-2).

-- - No media-specific criterion

NA - not analyzed

SoPC - Substance of potential concern

^a Arithmetic and geometric means were calculated using detected values and one-half the reported instrument detection limit for undetected values.

^b Number of criteria exceedances for detected samples is followed by the number of samples in which the substance was not detected and the detection limit is greater than the criteria value.

^c Soil screening level for migration to groundwater with a dilution attenuation factor of 1.

Table 4-3a. Summary of SoPCs in offsite surface soil

Analyte	Concentration units	Number of analyses	Number of undetected values	Minimum detected value	Maximum detected value	Arithmetic mean value ^a	Geometric mean value ^a	Residential Direct Contact Soil Cleanup Criteria (NJAC 7:26; 5/12/99)		Ecological Criteria Screening ^c	
								No. of exceedances ^b	Criteria Value	No. of exceedances ^b	Criteria Value
Mercury											
Mercury (total)	mg/kg	26	2	0.535	554	33	4	8(0)	14	24(2)	0.00051
Metals											
Copper	mg/kg	22	0	13.5	202	60	50	0(0)	600	10(0)	60
Lead	mg/kg	22	0	3.61	410	150	100	1(0)	400	19(0)	40
Zinc	mg/kg	22	0	26.9	777	250	180	0(0)	1,500	22(0)	8.5
Semivolatile Organic Compounds											
Benz[a]anthracene	µg/kg	22	1	77	15,000	2,000	800	8(1)	900	--	--
Benzo[a]pyrene	µg/kg	22	1	67	18,000	2,000	900	10(1)	660	0(0)	20,000
Benzo[b]fluoranthene	µg/kg	22	1	130	22,000	3,000	1,000	12(1)	900	--	--
Benzo[k]fluoranthene	µg/kg	22	2	110	11,000	1,000	500	3(1)	900	--	--
Dibenz[a,h]anthracene	µg/kg	22	9	39	2,100	500	100	3(1)	660	--	--
Indeno[1,2,3-cd]pyrene	µg/kg	22	4	110	6,800	1,000	400	4(1)	900	--	--

Notes: Analytes shown in bold are media-specific SoPCs.

-- - No media specific criterion

^a Arithmetic and geometric means were calculated using detected values and one-half the reported instrument detection limit (IDL) for undetected values.

^b Number of criteria exceedances for detected samples is followed by the number of samples in which the substance was not detected and the detection limit is greater than the criteria value.

^c See Appendix B for ecological criteria sources and citations.

Table 4-3b. Summary of SoPCs in offsite surface soil -- locations adjacent to Site

Analyte	Concentration units	Number of analyses	Number of undetected values	Minimum detected value	Maximum detected value	Arithmetic mean value ^a	Geometric mean value ^a	Residential Direct Contact Soil Cleanup Criteria (NJAC 7:26; 5/12/99)		Ecological Criteria Screening ^c	
								No. of exceedances ^b	Criteria Value	No. of exceedances ^b	Criteria Value
Mercury											
Mercury (total)	mg/kg	12	0	0.644	554	65	10	7(0)	14	12(0)	0.00051
Metals											
Copper	mg/kg	8	0	15.7	202	81	63	0(0)	600	6(0)	60
Lead	mg/kg	8	0	23	410	170	130	1(0)	400	7(0)	40
Zinc	mg/kg	8	0	86.8	459	290	250	0(0)	1,500	8(0)	8.5
Semivolatile Organic Compounds											
Benz[a]anthracene	µg/kg	8	0	77	2,300	900	600	3(0)	900	--	--
Benzo[a]pyrene	µg/kg	8	0	67	2,200	900	600	4(0)	660	0(0)	20,000
Benzo[b]fluoranthene	µg/kg	8	0	130	2,800	1,300	1,000	5(0)	900	--	--
Benzo[k]fluoranthene	µg/kg	8	1	210	820	400	320	0(0)	900	--	--
Dibenz[a,h]anthracene	µg/kg	8	4	62	120	80	80	0(0)	660	--	--
Indeno[1,2,3-cd]pyrene	µg/kg	8	1	220	720	390	320	0(0)	900	--	--

Notes: Analytes shown in bold are media-specific SoPCs.

-- - No media specific criterion

^a Arithmetic and geometric means were calculated using detected values and one-half the reported instrument detection limit (IDL) for undetected values.

^b Number of criteria exceedances for detected samples is followed by the number of samples in which the substance was not detected and the detection limit is greater than the criteria value.

^c See Appendix B for ecological criteria sources and citations.

Table 4-3c. Summary of SoPCs in offsite surface soil -- locations not adjacent to Site

Analyte	Concentration units	Number of analyses	Number of undetected values	Minimum detected value	Maximum detected value	Arithmetic mean value ^a	Geometric mean value ^a	Residential Direct Contact Soil Cleanup Criteria (NJAC 7:26; 5/12/99)		Ecological Criteria Screening ^c	
								No. of exceedances ^b	Criteria Value	No. of exceedances ^b	Criteria Value
Mercury											
Mercury (total)	mg/kg	14	2	0.535	16.6	4.8	1.8	1(0)	14	12(2)	0.00051
Metals											
Copper	mg/kg	14	0	13.5	120	50	50	0(0)	600	4(0)	60
Lead	mg/kg	14	0	3.61	392	139	85	0(0)	400	12(0)	40
Zinc	mg/kg	14	0	26.9	777	230	150	0(0)	1,500	14(0)	8.5
Semivolatile Organic Compounds											
Benz[a]anthracene	µg/kg	14	1	140	15,000	3,000	1,000	5(1)	900	--	--
Benzo[a]pyrene	µg/kg	14	1	200	18,000	3,000	1,000	6(1)	660	0(0)	20,000
Benzo[b]fluoranthene	µg/kg	14	1	310	22,000	4,000	2,000	7(1)	900	--	--
Benzo[k]fluoranthene	µg/kg	14	1	110	11,000	2,000	600	3(1)	900	--	--
Dibenz[a,h]anthracene	µg/kg	14	5	39	2100	700	200	3(1)	660	--	--
Indeno[1,2,3-cd]pyrene	µg/kg	14	3	110	6,800	1400	500	4(1)	900	--	--

Notes: Analytes shown in bold are media-specific SoPCs.

-- - No media specific criterion

^a Arithmetic and geometric means were calculated using detected values and one-half the reported instrument detection limit (IDL) for undetected values.

^b Number of criteria exceedances for detected samples is followed by the number of samples in which the substance was not detected and the detection limit is greater than the criteria value.

^c See Appendix B for ecological criteria sources and citations.

Table 4-3d. Summary of SoPCs in offsite soil boreholes

Analyte	Concentration Units	Number of Analyses	Number of Undetected Values	Minimum Detected Value	Maximum Detected Value	Arithmetic Mean Value ^a	Geometric Mean Value ^a	Residential Direct Contact Soil Cleanup Criteria (NJAC 7:26; 5/12/99)	
								No. of Exceedances ^b	Criteria Value
Mercury (total)^c	mg/kg	21	18	0.04	240	42.8	2.9	11(0)	14

Note: SoPC - substance of potential concern

^a Arithmetic and geometric means were calculated using detected values and one-half the reported instrument detection limit for undetected values.

^b Number of criteria exceedances for detected samples is followed by the number of samples in which the substance was not detected and the detection limit is greater than the criteria value.

^c Media-specific SoPC.

Table 4-4a. Summary of SoPCs in groundwater (OU1) -- Phase I investigation

Analyte	Concentration Units	Number of Analyses	Number of Undetected Values	Minimum Detected Value	Maximum Detected Value	Arithmetic Mean Value ^a	Geometric Mean Value ^a	Drinking Water MCL Standard (EPA January 2002)		Groundwater Quality Standards (NJAC 7:9-6; 1/7/96)		Surface Water Quality Standards (NJAC 7:9B; 4/98) ^c	
								No. of Exceedances	Criteria Value	No. of Exceedances ^b	Criteria Value	No. of Exceedances	Criteria Value
Mercury													
Mercury (total)	μg/L	13	8	0.5	8.2	0.9	0.3	1 (0)	2	1 (0)	2	2 (0)	0.144
<i>Methylmercury</i>	μg/L	13	0	0.00014	0.02	0.0044	0.0025	--	--	--	--	--	--
Metals													
Antimony	μg/L	13	13	ND	ND	1.7	1.7	0 (0)	6	0 (0)	20	0 (0)	12.2
Arsenic	μg/L	13	10	2.6	14.6	3.2	1.9	2 (0)	10	2 (0)	8	2 (6)	0.017
Cadmium	μg/L	13	11	1.1	2.5	0.4	0.2	0 (0)	5	0 (0)	4	0 (0)	10
Iron	μg/L	13	0	152	37,500	15,000	7,000	--	--	12 (0)	300	--	--
Lead	μg/L	13	11	0.8	0.9	0.6	0.6	0 (0)	15	0 (0)	10	0 (0)	5
Manganese	μg/L	13	0	74.1	3,880	1,390	820	--	--	13 (0)	50	--	--
Nickel	μg/L	13	0	2.1	117	22	8	--	--	2 (0)	100	0 (0)	516
Selenium	μg/L	13	12	2.34	2.34	1.3	1.3	0 (0)	50	--	--	0 (0)	10
Sodium	μg/L	13	0	31,700	485,000	121,000	75,000	--	--	8 (0)	50,000	--	--
Thallium	μg/L	13	11	5	5.4	3.4	3.2	2 (9)	2	0 (0)	10	2 (6)	1.7
Semivolatile Organic Compounds													
bis[2-Ethylhexyl]phthalate	μg/L	13	12	2	2	20	6	0 (1)	6	0 (1)	30	1 (7)	1.76
Volatile Organic Compounds													
Benzene	μg/L	13	11	18	140	20	7	2 (0)	5	2 (11)	1	0 (8)	0.15
Chlorobenzene	μg/L	13	9	3	15	5	5	0 (0)	100	2 (9)	4	0 (0)	22
1,2-Dichloroethene isomers	μg/L	13	11	2	45	8	6	--	--	1 (0)	10	--	--
1,1,2,2-Tetrachloroethane	μg/L	13	13	ND	ND	6	5	--	--	0 (13)	2	0 (8)	1.72
Toluene	μg/L	13	12	1,700	1,700	100	8	1 (0)	1,000	1 (0)	1,000	0 (0)	7,440
Xylene isomers	μg/L	13	12	390	390	30	7	0 (0)	10,000	1 (0)	40	--	--

Notes: Analytes shown in bold are media-specific SoPCs; analytes shown in italics are not media-specific SoPCs, but have been provided to support the assessment of SoPC transport and fate.

-- - No criterion for this analyte

EPA - U.S. Environmental Protection Agency

MCL - Maximum Contaminant Level

ND - Not Detected

SoPC - Substance of potential concern

^a Arithmetic and geometric means were calculated using detected values and one-half the reported instrument detection limit for undetected values.

^b Number of criteria exceedances for detected samples is followed by the number of samples in which the substance was not detected and the detection limit is greater than the criteria value.

^c n=8. Only 7 perimeter wells adjacent to surface water bodies (MW-1, 3, 4, 5, 6, 8, and 12) were compared to SWQS criteria. There were two values, representing duplicates, for MW-6.

Table 4-4b. Summary of SoPCs in groundwater (OU1) -- Phase IA investigation

Analyte	Concentration Units	Number of Analyses	Number of Undetected Values	Minimum Detected Value	Maximum Detected Value	Arithmetic Mean Value ^a	Geometric Mean Value ^a	Drinking Water MCL Standard (EPA January 2002)		Groundwater Quality Standards (NJAC 7:9-6; 1/7/96)		Surface Water Quality Standards (NJAC 7:9B; 4/98) ^c	
								No. of Exceedances	Criteria Value	No. of Exceedances ^b	Criteria Value	No. of Exceedances	Criteria Value
Mercury													
Mercury (total)	μg/L	16	0	0.01084	54.243	7.042	0.561	3 (0)	2	3 (0)	2	5 (0)	0.144
<i>Methylmercury</i>	μg/L	16	0	0.00012	0.03528	0.0098	0.0034	--	--	--	--	--	--
Metals													
Antimony	μg/L	NA	NA	NA	NA	NA	NA	NA	6	NA	20	NA	12.2
Arsenic	μg/L	16	13	6.4	21.4	5	3.7	2 (0)	10	2 (0)	8	0(8)	0.017
Cadmium	μg/L	16	4	0.89	5.7	2	1	1 (0)	5	1 (0)	4	0 (0)	10
Iron	μg/L	16	2	386	27,000	9,000	3,000	--	--	14 (0)	300	--	--
Lead	μg/L	16	9	3.4	13.9	3.6	2.4	0 (0)	15	1 (0)	10	4 (0)	5
Manganese	μg/L	16	0	7.2	6,580	1,390	500	--	--	15 (0)	50	--	--
Nickel	μg/L	16	7	2	45	8	3	--	--	0 (0)	100	0 (0)	516
Selenium	μg/L	16	11	4.8	13.4	3.9	2.9	0 (0)	50	--	--	1 (0)	10
Sodium	μg/L	NA	NA	NA	NA	NA	NA	NA	--	NA	50,000	NA	--
Thallium	μg/L	16	13	5.5	14.7	3.8	2.9	3 (13)	2	2 (0)	10	1 (7)	1.7
Semivolatile Organic Compounds													
bis[2-Ethylhexyl]phthalate	μg/L	2	2	ND	ND	5.3	5.2	0 (0)	6	0 (0)	30	NA	1.76
Volatile Organic Compounds													
Benzene	μg/L	16	9	1.2	14	3	1	5 (0)	5	7 (0)	1	3 (5)	0.15
Chlorobenzene	μg/L	16	12	1.9	28	4	3	0 (0)	100	2 (0)	4	1 (0)	22
1,2-Dichloroethene isomers	μg/L	NA	NA	NA	NA	NA	NA	NA		NA		NA	--
<i>1,1,2,2-Tetrachloroethane</i>	μg/L	NA	NA	NA	NA	NA	NA	NA		NA		NA	1.72
Toluene	μg/L	16	14	320	340	40	5	0 (0)	1,000	0 (0)	1,000	0 (0)	7,440
meta- & para-Xylenes	μg/L	16	14	48	54	9	4	0 (0)	10,000	2 (0)	40	--	--
ortho-Xylene	μg/L	16	14	20	23	5	3	0 (0)	10,000	0 (0)	40	--	--

Notes: Analytes shown in bold are media-specific SoPCs; analytes shown in italics are not media-specific SoPCs, but have been provided to support the assessment of SoPC transport and fate.

-- - No criterion for this analyte

EPA - U.S. Environmental Protection Agency

MCL - Maximum Contaminant Level

NA - Not analyzed

ND - Not detected

SoPC - Substance of potential concern

^a Arithmetic and geometric means were calculated using detected values and one-half the reported instrument detection limit for undetected values.

^b Number of criteria exceedances for detected samples is followed by the number of samples in which the substance was not detected and the detection limit is greater than the criteria value.

^c n=8. Only 8 perimeter wells adjacent to surface water bodies (MW-1, 3, 4, 5, 6, 8, 12, and 15) were compared to SWQS criteria.

Table 4-4c. Summary of SoPCs in groundwater (OU1) -- supplemental Phase IA investigation

Analyte	Concen- tration Units	Number of Analyses	Number of Undetected Values	Minimum Detected Value	Maximum Detected Value	Arithmetic Mean Value ^a	Geometric Mean Value ^a	Drinking Water MCL Standard (EPA January 2002)		Groundwater Quality Standards (NJAC 7:9-6; 1/7/96)		Surface Water Quality Standards (NJAC 7:9B; 4/98)	
								No. of Exceedances	Criteria Value	No. of Exceedances ^b	Criteria Value	No. of Exceedances	Criteria Value
Mercury													
Mercury - filtered	μg/L	4	0	0.9235	9.8467	5.1374	3.6264	3 (0)	2	3 (0)	2	4 (0)	0.144
Mercury - unfiltered	μg/L	4	0	2.8255	16.062	10.06	8.28	4 (0)	2	4 (0)	2	4 (0)	0.144

Note: -- - No criterion for this analyte
EPA - U.S. Environmental Protection Agency
MCL - Maximum Contaminant Level
SoPC - Substance of potential concern

^a Arithmetic and geometric means were calculated using detected values and one-half the reported instrument detection limit for undetected values.

^b Number of criteria exceedances for detected samples is followed by the number of samples in which the substance was not detected and the detection limit is greater than the criteria value.

Table 4-4d. Summary of SoPCs in groundwater (OU1) -- Phase IA SFI

Analyte	Concentration Units	Number of analyses	Number of undetected values	Minimum detected value	Maximum detected value	Arithmetic mean value ^a	Geometric mean value ^a	Drinking Water MCL (EPA January 2002 ^c)		Groundwater Quality Standards (NJAC 7:9-6; 1/7/96)		Surface Water Quality Standards ^c (N.J.A.C. 7:9B; 4/98)	
								No. of exceedances ^b	Criteria value	No. of exceedances ^b	Criteria value	No. of exceedances ^b	Criteria value
Mercury													
Mercury (total)	µg/L	15	0	0.017	22.9	2.3	0.187	3	2	3(0)	2	2(0)	0.144
Mercury (dissolved)	µg/L	15	4	0.010	12.6	0.984	0.038	1(0)	2	1(0)	2	1(0)	0.144
Metals													
Arsenic	µg/L	15	12	10.9	41.5	5.71	2.69	3(0)	10	3(0)	8	2(6)	0.017
<i>Barium</i>	µg/L	15	0	75.4	1,100	370.8	250.0	0(0)	2,000	0(0)	2,000	0(0)	2,000
Cadmium	µg/L	15	14	0.841	0.841	0.289	0.271	0(0)	5	0(0)	4	0(0)	10
<i>Copper</i>	µg/L	15	15	ND	ND	10	10	0(0)	1,300	0(0)	1,000	--	--
Iron	µg/L	15	1	100	31,700	12,226	3,866	--	--	12(0)	300	--	--
Lead	µg/L	15	15	ND	ND	2.5	2.5	0(0)	15	0(0)	10	0(8 ^d)	5
Manganese	µg/L	15	1	182	4,180	1,569	840	--	--	14(0)	50	--	--
Nickel	µg/L	15	15	ND	ND	20	20	--	--	0(0)	100	0(0)	516
Thallium	µg/L	15	14	0.2973	0.2973	0.1132	0.1075	0(0)	2	0(0)	10	0(0)	1.7
<i>Vanadium</i>	µg/L	15	14	62.9	62.9	27.5	26.6	--	--	--	--	--	--

Notes: Analytes shown in bold are media-specific SoPCs; analytes shown in italics are not media-specific SoPCs, but have been provided to support the assessment of SoPC transport and fate.

-- - No media specific criterion

MCL - Maximum Contaminant Level

NA - Not analyzed

ND - None detected

SFI - Supplemental Field Investigation

^a Arithmetic and geometric means were calculated using detected values and one-half the reported instrument detection limit (IDL) for undetected values.

^b Number of criteria exceedances for detected samples is followed by the number of samples in which the substance was not detected and the detection limit is greater than the criteria value.

^c n=8. Only 8 perimeter wells (MW-1,3,4,5,6,8,12,and 15) adjacent to surface water bodies were compared to SWQS criteria.

^d The IDL was equivalent to the surface water quality standard.

Table 4-5a. Summary of SoPCs in seeps (OU1) -- Phase I

Analyte	Concentration units	Number of analyses	Number of undetected values	Minimum detected value	Maximum detected value	Arithmetic mean value ^a	Geometric mean value ^a	Groundwater Quality Standards (NJAC 7:9-6; 1/7/96)		Surface Water Quality Standards (N.J.A.C. 7:9B; 4/98)	
								No. of exceedances ^b	Criteria Value	No. of exceedances ^b	Criteria Value
Mercury											
Mercury (total) - Filtered	µg/L	5	3	0.21	1.8	0.5	0.2	0(0)	2	2(3)	0.144
<i>Methylmercury - Filtered</i>	µg/L	5	0	0.00011	0.00221	0.00089	0.0005	--	--	--	--
Mercury (total) - Unfiltered	µg/L	5	0	2.1	104	35	19	5(0)	2	5(0)	0.144
<i>Methylmercury - Unfiltered</i>	µg/L	5	0	0.00074	0.0331	0.01508	0.00877	--	--	--	--
Filtered metals											
Arsenic	µg/L	5	3	2.2	2.4	1.6	1.5	0(0)	8	2(3)	0.017
Cadmium	µg/L	5	4	5.6	5.6	1.4	0.5	1(0)	4	0(0)	10
Iron	µg/L	5	1	141	524	210	100	1(0)	300	--	--
Lead	µg/L	5	4	1.4	1.4	0.6	0.5	0(0)	10	0(0)	5
Manganese	µg/L	5	0	200	1660	900	700	5(0)	50	--	--
Sodium	µg/L	5	0	742,000	1,610,000	1,310,000	1,260,000	5(0)	50,000	--	--
Thallium	µg/L	5	5	ND	ND	3.9	3.9	0(1)	10	0(5)	2
Unfiltered metals											
Arsenic	µg/L	5	1	2.7	30	9.5	5.1	2(0)	8	4(1)	0
Cadmium	µg/L	5	1	2	23.3	7.3	4	2(0)	4	1(0)	10
Iron	µg/L	5	0	1,430	23,600	10,900	7,200	5(0)	300	--	--
Lead	µg/L	5	0	10.5	219	84	53	5(0)	10	5(0)	5
Manganese	µg/L	5	0	295	1770	1,080	870	5(0)	50	--	--
Sodium	µg/L	5	0	240,000	1,580,000	1,140,000	950,000	5(0)	50,000	--	--
Thallium	µg/L	5	5	ND	ND	3.4	3.4	0(0)	10	0(5)	2
Semivolatile Organic Compounds											
bis[2-Ethylhexyl]phthalate	µg/L	5	3	2	4	4	4	0(0)	30	2(3)	2
Volatile Organic Compounds											
1,1,2,2-Tetrachloroethane	µg/L	5	5	ND	ND	5	5	0(5)	2	0(5)	2

Notes: Analytes shown in bold are media-specific SoPCs; analytes shown in italics are not media-specific SoPCs, but have been provided to support the assessment of SoPC transport and fate.

-- - No media specific criterion

ND - None detected

^a Arithmetic and geometric means were calculated using detected values and one-half the reported instrument detection limit (IDL) for undetected values.

^b Number of criteria exceedances for detected samples is followed by the number of samples in which the substance was not detected and the detection limit is greater than the criteria value.

Table 4-5b. Summary of SoPCs in seeps (OU1) -- Phase IA

								Groundwater Quality Standards (NJAC 7:9-6; 1/7/96)		Surface Water Quality Standards (N.J.A.C. 7:9B; 4/98)	
Analyte	Concentration units	Number of analyses	Number of undetected values	Minimum detected value	Maximum detected value	Arithmetic mean value ^a	Geometric mean value ^a	No. of exceedances ^b	Criteria Value	No. of exceedances ^b	Criteria Value
Mercury											
Mercury (total) - Filtered	µg/L	5	0	0.00244	0.06669	0.0297	0.0158	0(0)	2	0(0)	0.144
Methylmercury - Filtered	µg/L	5	0	0.00019	0.0023	0.0013	0.0008	--	--	--	--
Mercury (total) - Unfiltered	µg/L	5	0	0.00791	5.26	1.78	0.53	1(0)	2	4(0)	0.144
Methylmercury - Unfiltered	µg/L	5	0	0.00084	0.02914	0.00751	0.00302	--	--	--	--
Filtered metals											
Arsenic	µg/L	5	5	ND	ND	2.7	2.7	0(0)	8	0(5)	0.017
Cadmium	µg/L	5	5	ND	ND	0.31	0.31	0(0)	4	0(0)	10
Iron	µg/L	5	1	202	3,370	1,500	500	3(0)	300	--	--
Lead	µg/L	5	3	2.2	4	2	2	0(0)	10	0(0)	5
Manganese	µg/L	5	0	447	1,370	770	700	5(0)	50	--	--
Thallium	µg/L	5	5	ND	ND	2.2	2.2	0(0)	10	0(5)	1.7
Unfiltered Metals											
Arsenic	µg/L	5	5	ND	ND	2.7	2.7	0(0)	8	0(5)	0.017
Cadmium	µg/L	5	1	1	3.7	2	1	0(0)	4	0(0)	10
Iron	µg/L	5	0	2,230	8,430	4,600	4,110	5(0)	300	--	--
Lead	µg/L	5	0	4.9	64.5	24.6	16.7	3(0)	10	4(0)	5
Manganese	µg/L	5	0	502	1,480	820	750	5(0)	50	--	--
Thallium	µg/L	5	5	ND	ND	2.2	2.2	0(0)	10	0(5)	1.7

Notes: Analytes shown in bold are media-specific SoPCs; analytes shown in italics are not media-specific SoPCs, but have been provided to support the assessment of SoPC transport and fate.

-- - No media specific criterion

ND - None detected

^a Arithmetic and geometric means were calculated using detected values and one-half the reported instrument detection limit (IDL) for undetected values.

^b Number of criteria exceedances for detected samples is followed by the number of samples in which the substance was not detected and the detection limit is greater than the criteria value.

Table 4-6a. Summary of SoPCs in surface water (OU1) -- onsite basin only

								Surface Water Quality Standards ^c (N.J.A.C. 7:9B; 4/98)	
Analyte	Concentration units	Number of analyses	Number of undetected values	Minimum detected value	Maximum detected value	Arithmetic mean value ^a	Geometric mean value ^a	No. of exceedances ^b	Criteria value
Mercury									
Mercury (total) - Filtered	µg/L	2	2	ND	ND	0.1	0.1	0(2)	0.144
Methylmercury - Filtered	µg/L	2	0	0.00085	0.00098	0.00092	0.00091	--	--
Mercury (total) - Unfiltered	µg/L	2	0	0.0058	0.0176	0.0117	0.0101	2(0)	0.144
Methylmercury - Unfiltered	µg/L	2	0	0.00218	0.00233	0.00225	0.00225	--	--
Filtered Metals									
Lead	µg/L	2	1	4.70	4.7	2.6	1.5	0(0)	5
Unfiltered Metals									
Lead	µg/L	2	0	2	4.2	3.1	2.9	0(0)	5

Notes: Analytes shown in bold are media-specific SoPCs; analytes shown in italics are not media-specific SoPCs, but have been provided to support the assessment of SoPC transport and fate.

-- - No media specific criterion

ND - None detected

^a Arithmetic and geometric means were calculated using detected values and one-half the reported instrument detection limit (IDL) for undetected values.

^b Number of criteria exceedances for detected samples is followed by the number of samples in which the substance was not detected and the detection limit is greater than the criteria value.

Table 4-6b. Summary of SoPCs in surface water (OU1) -- West Ditch only

								Surface Water Quality Standards ^c (N.J.A.C. 7:9B; 4/98)	
Analyte	Concentration units	Number of analyses	Number of undetected values	Minimum detected value	Maximum detected value	Arithmetic mean value ^a	Geometric mean value ^a	No. of exceedances ^b	Criteria value
Mercury									
Mercury (total) - Unfiltered	µg/L	3	0	0.402	0.738	0.573	0.556	3(0)	0.144
Methylmercury - Unfiltered	µg/L	3	0	0.00114	0.00277	0.00184	0.00172	--	--
Unfiltered Metals									
Lead	µg/L	3	0	4	19	9.0	7	2(0)	5

Notes: Analytes shown in bold are media-specific SoPCs; analytes shown in italics are not media-specific SoPCs, but have been provided to support the assessment of SoPC transport and fate.

-- - No media specific criterion

ND - None detected

^a Arithmetic and geometric means were calculated using detected values and one-half the reported instrument detection limit (IDL) for undetected values.

^b Number of criteria exceedances for detected samples is followed by the number of samples in which the substance was not detected and the detection limit is greater than the criteria value.

Table 4-6c. Summary of SoPCs in surface water (OU2)

								Surface Water Quality Standards ^c (N.J.A.C. 7:9B; 4/98)	
Analyte	Concentration units	Number of analyses	Number of undetected values	Minimum detected value	Maximum detected value	Arithmetic mean value ^a	Geometric mean value ^a	No. of exceedances ^b	Criteria value
Mercury									
Mercury (total) - Filtered	μg/L	15	13	0.2	0.24	0.12	0.11	2(13)	0.144
Methylmercury - Filtered	μg/L	15	0	0.00008	0.00047	0.00027	0.00025	--	--
Mercury (total) - Unfiltered	μg/L	15	1	0.74	15.6	2.7	1.3	14(1)	0.144
Methylmercury - Unfiltered	μg/L	15	0	0.00058	0.00464	1.35	1.07	--	--
Filtered Metals									
Arsenic	μg/L	15	15	ND	ND	1.2	1.2	0(15)	0.017
Lead	μg/L	15	15	ND	ND	0.5	0.5	0(0)	5
Thallium	μg/L	15	14	5.3	5.3	2.7	2.6	1(14)	1.7
Unfiltered Metals									
Arsenic	μg/L	15	12	2.9	14.2	2.9	2.2	3(12)	0.017
Lead	μg/L	15	5	1.2	119	11	2	4(0)	5
Thallium	μg/L	15	13	6.7	9.5	3.6	3.2	2(13)	1.70
Volatile Organic Compounds									
1,1,2,2-Tetrachloroethane	μg/L	15	14	3	3	5	5	1(14)	1.72
Semivolatile Organic Compounds									
bis[2-Ethylhexyl]phthalate	μg/L	15	10	1	4	4	4	3(10)	1.76

Notes: Analytes shown in bold are media-specific SoPCs; analytes shown in italics are not media-specific SoPCs, but have been provided to support the assessment of SoPC transport and fate.

-- - No media specific criterion

ND - None detected

^a Arithmetic and geometric means were calculated using detected values and one-half the reported instrument detection limit (IDL) for undetected values.

^b Number of criteria exceedances for detected samples is followed by the number of samples in which the substance was not detected and the detection limit is greater than the criteria value.

Table 4-7a. Summary of SoPCs in sediment (OU1) -- onsite basin only

Analyte	Concentration units	Number of analyses	Number of undetected values	Minimum detected value	Maximum detected value	Arithmetic mean value ^a	Geometric mean value ^a	NJ Sediment Guidance LEL		NJ Sediment Guidance SEL ^c
								No. of exceedances ^b	Criteria value	No. of Exceedances ^b
Mercury										
Mercury (total)	mg/kg	2	0	1,280	1,290	1,280	1,280	2(0)	0.2	2(0)
Mercury (total); 0-2 cm	mg/kg	2	0	856	1,180	1020	1010	2(0)	0.2	2(0)
<i>Methylmercury</i>	mg/kg	2	0	0.0982	0.126	0.112	0.111	--	--	--
Metals										
Arsenic	mg/kg	2	0	3.6	8.8	6.2	5.6	1(0)	6	2(0)
Cadmium	mg/kg	2	0	0.9	1.6	1.2	1.2	2(0)	1	1(0)
Chromium	mg/kg	2	0	55.4	65.6	60.5	60.3	2(0)	26	2(0)
Copper	mg/kg	2	0	94	136	115	113	2(0)	16	2(0)
Lead	mg/kg	2	0	188	469	329	297	2(0)	31	2(0)
Nickel	mg/kg	2	0	14.2	28.1	21.2	20	1(0)	16	2(0)
Silver	mg/kg	2	0	1.1	2.4	1.8	1.7	2(0)	1	--
Zinc	mg/kg	2	0	556	844	700	685	2(0)	120	2(0)
PCBs										
Aroclor® 1248	μg/kg	2	0	190	240	210	210	2(0)	30	--
Aroclor® 1260	μg/kg	2	0	260	490	370	360	2(0)	5	--
Semivolatile Organic Compounds										
Acenaphthene	μg/kg	2	1	100	100	450	280	1(1)	16	--
Acenaphthylene	μg/kg	2	2	ND	ND	480	360	0(2)	44	--
Anthracene	μg/kg	2	0	250	350	300	290	2(0)	220	--
Benz[a]anthracene	μg/kg	2	0	900	1,700	1,300	1,200	2(0)	320	--
Benzo[a]pyrene	μg/kg	2	0	800	1,600	1,200	1,100	2(0)	370	--
Benzo[ghi]perylene	μg/kg	2	0	580	1,200	900	800	2(0)	170	--
Benzo[k]fluoranthene	μg/kg	2	0	340	660	500	470	2(0)	240	--
Chrysene	μg/kg	2	0	900	1,600	1,200	1,200	2(0)	340	--
Dibenz[a,h]anthracene	μg/kg	2	0	170	320	250	230	2(0)	60	--
Fluoranthene	μg/kg	2	0	1,700	2,800	2,200	2,200	2(0)	750	--
<i>Fluorene</i>	μg/kg	2	0	110	170	140	140	0(0)	190	--
<i>2-Methylnaphthalene</i>	μg/kg	2	2	ND	ND	480	360	0(2)	70	--
<i>Naphthalene</i>	μg/kg	2	2	ND	ND	480	360	0(2)	160	--
Phenanthrene	μg/kg	2	0	1,200	1,800	1,500	1,500	2(0)	560	--
Pyrene	μg/kg	2	0	1,610	2,900	2,300	2,200	2(0)	490	--

Notes: Analytes shown in bold are media-specific SoPCs; analytes shown in italics are not media-specific SoPCs, but have been provided to support the assessment of SoPC transport and fate.

-- - No media specific criterion

ND - None detected

^a Arithmetic and geometric means were calculated using detected values and one-half the reported instrument detection limit (IDL) for undetected values.

^b Number of criteria exceedances for detected samples is followed by the number of samples in which the substance was not detected and the detection limit is greater than the criteria value.

^c SEL criteria are not shown because they are TOC dependent. The sample's TOC value was used where available. A default value of 1% was used where TOC was not available.

Table 4-7b. Summary of SoPCs in sediment (OU1) -- West Ditch only

Analyte	Concentration units	Number of analyses	Number of undetected values	Minimum detected value	Maximum detected value	Arithmetic mean value ^a	Geometric mean value ^a	NJ Sediment Guidance LEL		NJ Sediment Guidance SEL ^c
								No. of exceedances ^b	Criteria value	No. of Exceedances ^b
Mercury										
Mercury (total)	mg/kg	3	0	19.0	155	64.8	39.4	3(0)	0.2	3(0)
Methylmercury	mg/kg	3	0	0.01191	0.06654	0.03091	0.02246	--	--	--
Metals										
Arsenic	mg/kg	3	0	2.6	5.1	4.2	4	0(0)	6	3(0)
Cadmium	mg/kg	3	0	2.2	9.1	5.3	4.5	3(0)	1	3(0)
Chromium	mg/kg	3	0	88.4	156	131	127	3(0)	26	3(0)
Copper	mg/kg	3	0	143	194	162	160	3(0)	16	3(0)
Lead	mg/kg	3	0	224	274	246	245	3(0)	31	3(0)
Nickel	mg/kg	3	0	24.1	29.2	27.1	27	3(0)	16	3(0)
Silver	mg/kg	3	2	4.3	4.3	1.5	0.3	1(0)	1	--
Zinc	mg/kg	3	0	434	3,540	1,920	1,400	3(0)	120	3(0)
PCBs										
Aroclor® 1248	µg/kg	NA	NA	NA	NA	NA	NA	NA	30	--
Aroclor® 1260	µg/kg	NA	NA	NA	NA	NA	NA	NA	5	--
Semivolatile Organic Compounds										
Acenaphthene	µg/kg	3	3	ND	ND	440	440	0(3)	16	--
Acenaphthylene	µg/kg	3	1	180	270	280	270	2(1)	44	--
Anthracene	µg/kg	3	0	170	350	270	260	2(0)	220	--
Benz[a]anthracene	µg/kg	3	0	230	560	350	320	1(0)	320	--
Benzo[a]pyrene	µg/kg	3	0	300	630	410	390	1(0)	370	--
Benzo[ghi]perylene	µg/kg	3	0	270	550	370	350	3(0)	170	--
Benzo[k]fluoranthene	µg/kg	3	0	280	580	380	360	3(0)	240	--
Chrysene	µg/kg	3	0	330	690	470	440	2(0)	340	--
Dibenz[a,h]anthracene	µg/kg	3	0	91	270	180	160	3(0)	60	--
Fluoranthene	µg/kg	3	0	510	1100	800	700	1(0)	750	--
Fluorene	µg/kg	3	3	ND	ND	440	440	0(3)	190	--
2-Methylnaphthalene	µg/kg	NA	NA	NA	NA	NA	NA	NA	70	--
Naphthalene	µg/kg	3	2	100	100	320	260	0(2)	160	--
Phenanthrene	µg/kg	3	0	180	390	270	250	0(0)	560	--
Pyrene	µg/kg	3	0	380	780	560	530	2(0)	490	--

Notes: Analytes shown in bold are media-specific SoPCs; analytes shown in italics are not media-specific SoPCs, but have been provided to support the assessment of SoPC transport and fate.

-- - No media specific criterion

NA - Not analyzed

ND - None detected

^a Arithmetic and geometric means were calculated using detected values and one-half the reported instrument detection limit (IDL) for undetected values.

^b Number of criteria exceedances for detected samples is followed by the number of samples in which the substance was not detected and the detection limit is greater than the criteria value.

^c SEL criteria are not shown because they are TOC dependent. The sample's TOC value was used where available. A default value of 1% was used where TOC was not available.

Table 4-7c. Summary of SoPCs in streambed sediment (OU2)

Analyte	Concentration units	Number of analyses	Number of undetected values	Minimum detected value	Maximum detected value	Arithmetic mean value ^a	Geometric mean value ^a	NJ Sediment		
								NJ Sediment Guidance LEL	Guidance SEL ^c	No. of Exceedances ^b
Mercury										
Mercury (total)	mg/kg	7	1	33.8	70	52.8	23.2	6(0)	0.15	6(1)
Mercury (total); 0-2 cm	mg/kg	7	0	0.89	11,100	1700	80	7(0)	0.15	7(0)
<i>Methylmercury</i>	mg/kg	7	0	0.00037	0.0204	0.0103	0.007	--	--	--
Metals										
Arsenic	mg/kg	7	0	6.6	24.6	13.2	11.5	7(0)	6	7(0)
Cadmium	mg/kg	7	1	6.8	17.1	10.3	5	6(0)	1	6(0)
Chromium	mg/kg	7	0	18	930	340	220	6(0)	26	7(0)
Copper	mg/kg	7	0	11.1	287	160	120	6(0)	16	7(0)
Lead	mg/kg	7	0	20.5	232	160	130	6(0)	31	7(0)
Nickel	mg/kg	7	0	14.8	66.4	35	32	6(0)	16	7(0)
Silver	mg/kg	7	1	1.4	4.8	2.8	2.1	6(0)	1	--
Zinc	mg/kg	7	0	56.1	7,300	2,400	1,100	6(0)	120	7(0)
PCBs										
Aroclor® 1248	µg/kg	7	0	30	4,700	2,400	1,300	6(0)	30	0(0)
Aroclor® 1260	µg/kg	7	5	320	430	150	90	2(5)	5	0(0)
Semivolatile Organic Compounds										
Acenaphthene	µg/kg	7	4	110	250	1,500	500	3(4)	16	--
Acenaphthylene	µg/kg	7	4	100	380	1,500	500	3(4)	44	--
Anthracene	µg/kg	7	4	250	960	1,600	700	3(4)	220	0(0)
Benz[a]anthracene	µg/kg	7	2	370	1,800	1,900	1,000	5(2)	320	0(0)
Benzo[a]pyrene	µg/kg	7	2	450	1,600	1,900	1,100	5(2)	370	0(0)
Benzo[g,h,i]perylene	µg/kg	7	2	400	730	1,600	700	5(2)	170	0(1)
Benzo[k]fluoranthene	µg/kg	7	2	170	690	1,500	500	3(2)	240	0(0)
Chrysene	µg/kg	7	2	460	1,800	2,000	1,100	5(2)	340	0(0)
Dibenz[a,h]anthracene	µg/kg	7	4	190	250	1,500	500	3(4)	60	0(1)
Fluoranthene	µg/kg	7	1	750	4,000	2,000	1,500	5(0)	750	0(0)
Fluorene	µg/kg	7	5	100	560	1,500	500	1(5)	190	0(1)
Indeno[1,2,3-cd]pyrene	µg/kg	7	2	350	850	1,600	800	5(2)	200	0(1)
2-Methylnaphthalene	µg/kg	7	6	140	140	1,500	500	1(6)	70	--
Naphthalene	µg/kg	7	6	640	640	1,600	700	1(6)	160	--
Phenanthrene	µg/kg	7	3	440	4,200	2,200	1,100	3(2)	560	0(0)
Pyrene	µg/kg	7	1	750	3,100	1,600	1,300	6(1)	490	0(0)

Notes: Analytes shown in bold are media-specific SoPCs; analytes shown in italics are not media-specific SoPCs, but have been provided to support the assessment of SoPC transport and fate.

-- - No media specific criterion

^a Arithmetic and geometric means were calculated using detected values and one-half the reported instrument detection limit (IDL) for undetected values.

^b Number of criteria exceedances for detected samples is followed by the number of samples in which the substance was not detected and the detection limit is greater than the criteria value.

^c SEL criteria are not shown because they are TOC dependent. The sample's TOC value was used where available. A default value of 1% was used where TOC was not available.

Table 4-7d. Summary of SoPCs in marsh soils/sediment (OU2)

Analyte	Concentration units	Number of analyses	Number of undetected values	Minimum detected value	Maximum detected value	Arithmetic mean value ^a	Geometric mean value ^a	NJ Sediment Guidance LEL		NJ Sediment Guidance SEL ^c
								No. of Exceedances ^b	Criteria value	No. of Exceedances ^b
Mercury										
Mercury (total)	mg/kg	19	0	25.1	1090	270	170	19(0)	0.2	19(0)
<i>Methylmercury</i>	mg/kg	19	0	0.00391	0.233	0.059	0.03	--	--	--
Metals										
Arsenic	mg/kg	19	1	15.6	150	40	30	18(0)	6	18(1)
Cadmium	mg/kg	19	0	3.8	68.3	22.2	16.2	19(0)	1	19(0)
Chromium	mg/kg	19	0	142	2,170	1,000	800	19(0)	26	19(0)
Copper	mg/kg	19	0	44.2	730	360	300	19(0)	16	19(0)
Lead	mg/kg	19	0	51.6	401	280	250	19(0)	31	19(0)
Nickel	mg/kg	19	0	18.2	274	140	120	19(0)	16	19(0)
Silver	mg/kg	19	2	2.1	9.6	5.3	3.9	17(0)	1	--
Zinc	mg/kg	19	0	868	22,700	5,000	3,000	19(0)	120	19(0)
Semivolatile Organic Compounds										
Acenaphthene	μg/kg	19	18	110	110	600	550	1(18)	16	--
Acenaphthylene	μg/kg	19	18	480	480	620	590	1(18)	44	--
Anthracene	μg/kg	19	17	95	1,100	600	600	1(17)	220	0(0)
Benz[a]anthracene	μg/kg	19	0	130	5,800	600	300	10(0)	320	0(0)
Benzo[a]pyrene	μg/kg	19	0	150	4,900	600	400	11(0)	370	0(0)
Benzo[g,h,i]perylene	μg/kg	19	0	100	2,700	500	400	17(0)	170	0(0)
Benzo[k]fluoranthene	μg/kg	19	7	120	1,600	500	300	3(7)	240	0(0)
Chrysene	μg/kg	19	0	160	5,600	700	500	13(0)	340	1(0)
Dibenz[a,h]anthracene	μg/kg	19	12	110	170	480	360	7(12)	60	0(6)
Fluoranthene	μg/kg	19	0	220	10,000	1,000	600	5(0)	750	0(0)
Fluorene	μg/kg	19	18	290	290	610	580	1(18)	190	0(4)
Indeno[1,2,3-cd]pyrene	μg/kg	19	0	95	3,200	500	400	15(0)	200	0(0)
2-Methylnaphthalene	μg/kg	19	18	85	85	600	540	1(18)	70	--
Naphthalene	μg/kg	19	17	170	440	590	540	2(17)	160	--
Phenanthrene	μg/kg	19	7	100	4,100	600	400	1(7)	560	0(0)
Pyrene	μg/kg	19	0	240	9,000	1,000	600	12(0)	490	1(0)

Notes: Analytes shown in bold are media-specific SoPCs; analytes shown in italics are not media-specific SoPCs, but have been provided to support the assessment of SoPC transport and fate.

-- - No media specific criterion

^a Arithmetic and geometric means were calculated using detected values and one-half the reported instrument detection limit (IDL) for undetected values.

^b Number of criteria exceedances for detected samples is followed by the number of samples in which the substance was not detected and the detection limit is greater than the criteria value.

^c SEL criteria are not shown because they are TOC dependent. The sample's TOC value was used where available. A default value of 1% was used where TOC was not available.

Table 5-1a. Summary of groundwater conventional analytes and field parameters for Phase I sampling

Analyte	Concentration units	Number of analyses	Number of undetected values	Minimum detected value	Maximum detected value	Arithmetic mean value ^a	Geometric mean value ^a
Conventional Analytes							
Biochemical oxygen demand	mg/L	12	6	5	100	27	12
Carbonate alkalinity	mg/L	12	0	140	1,400	691	574
Chemical oxygen demand	mg/L	12	0	9	140	66	52
Orthophosphate-phosphorus	mg/L	12	6	0.08	0.74	0.15	0.07
Petroleum hydrocarbons	mg/L	12	10	0.5	3.6	0.55	0.33
Sulfate	mg/L	12	4	8	730	100	22
Total chloride	mg/L	12	1	42	850	150	89
Total dissolved solids	mg/L	12	1	98	1,700	694	559
Field Parameters							
Color		12	0	NA	NA	NA	NA
Conductivity	μS/cm	12	0	390	2,544	1,255	1,097
Dissolved oxygen	mg/L	12	0	0	1.25	0.42	NC
Oxidation-reduction potential	mV	12	0	-138	41.5	-59.2	NC
pH	S.U.	12	0	6.19	7	6.57	6.56
Specific conductance	μS/cm	12	0	1.69	3,270	1,409	762
Temperature	°C	12	0	12.4	17.7	15	14.9
Turbidity	NTU	12	0	4.15	1,365	252	36

Notes: NA - Not applicable

NC - Not calculated: geometric mean can not be calculated because of negative values or values of 0

^aArithmetic and geometric means were calculated using detected values and one-half the reported IDL for undetected values.

Table 5-1b. Summary of groundwater conventional analytes and field parameters for Phase IA sampling

Analyte	Concentration units	Number of analyses	Number of undetected values	Minimum detected value	Maximum detected value	Arithmetic mean value ^a	Geometric mean value ^a
Conventional parameters							
Ammonia	mg/L	15	2	0.202	79.8	12.0	1.7
Biochemical Oxygen Demand-5 Day Test	mg/L	15	5	2	28.8	9.1	4.8
Chemical Oxygen Demand	mg/L	15	1	9.19	153	70	50
Nitrate	mg/L	15	12	0.553	5.51	0.83	0.39
Orthophosphate	mg/L	15	0	0.003	1.77	0.20	0.03
Petroleum hydrocarbons	mg/L	15	15	ND	ND	0.25	0.25
Sulfate	mg/L	15	2	4.77	896	133	37
Sulfides	mg/L	15	6	1	8.2	1.4	1.0
Total alkalinity	mg/L	15	0	104	1,310	592	482
Total chloride	mg/L	15	0	9.05	1,180	160	70
Dissolved organic carbon	mg/L	15	0	3.85	50.8	22.9	18.2
Total dissolved solids	mg/L	15	0	157	2,380	1,030	842
Field Parameters							
Color		13	0	NA	NA	NA	NA
Conductivity	mS/cm	13	0	0.775	196	15	2
Dissolved oxygen	mg/L	13	0	0	5.23	1.5	NC
Oxidation-reduction potential	mV	13	0	-268	98	-47.9	NC
pH	S.U.	13	0	6.45	8.17	6.82	6.80
Temperature	°C	13	0	10.6	17.2	13.6	13.5
Turbidity	NTU	13	0	0	49	8	--

Notes: ND - Not detected

NA - Not applicable

NC - Not calculated: geometric mean can not be calculated because of negative values or values of 0

^aArithmetic and geometric means were calculated using detected values and one-half the reported IDL for undetected values.

Table 5-1c. Summary of groundwater conventional analytes and field parameters for supplemental Phase IA sampling

Analyte	Concentration units	Number of analyses	Number of undetected values	Minimum detected value	Maximum detected value	Arithmetic mean value ^a	Geometric mean value ^a
Field Parameters							
Color		3	0	NA	NA	NA	NA
Conductivity	mS/cm	3	0	0.87	1.75	1.17	1.10
Dissolved Oxygen	mg/L	3	0	3.3	5.4	4.1	4.0
Oxidation-reduction potential	mV	3	0	-145	-43.5	-106	NC
pH	S.U.	3	0	6.83	7.76	7.24	7.23
TDS	mg/L	3	0	550	1,100	737	697
Temperature	°C	3	0	15.9	21.6	18.9	18.8
Turbidity	NTU	3	0	3.5	6	5	4

Notes: NA - Not applicable

NC - Not calculated: geometric mean can not be calculated because of negative values or values of 0

^aArithmetic and geometric means were calculated using detected values and one-half the reported IDL for undetected values.

Table 5-2. Characteristic values of landfill leachate in groundwater

Analyte	Units	Miller (1980) ^a			Bouwer (1978) ^b			U.S. EPA (1988b) ^c			
		Minimum	Maximum	Median	Normal range		Upper limits	Minimum	Maximum	Median	Average
					Minimum	Maximum					
Metals											
Arsenic	µg/L	--	--	--	--	--	--	0.2	982	13.5	41.8
Beryllium	µg/L	--	--	--	--	--	--	1	10	4.75	5.6
Cadmium	µg/L	--	--	--	--	--	--	0.7	150	13.5	22
Chromium	µg/L	--	--	--	--	--	--	0.5	1,900	60	175.4
Copper	µg/L	0	9,900	500	100	9,000	9,900	3	2,800	54	167.9
Iron	µg/L	0	2,820,000	94,000	100	1,700,000	5,500,000	220	2,280,000	95,150	221,000
Lead	µg/L	100	2,000	750	--	--	5,000	5	1,600	63	161.6
Manganese	µg/L	60	125,000	220	--	--	1,400,000	30	79,000	3,700	9,590
Total mercury	µg/L	--	--	--	--	--	--	0.1	9.8	0.6	2
Nickel	µg/L	--	--	--	10	800	--	20	2,227	170	325.5
Silver	µg/L	--	--	--	--	--	--	0.8	50	20	20.8
Thallium	µg/L	--	--	--	--	--	--	4	860	80	175.3
Zinc	µg/L	0	370,000	3,500	30	135,000	1,000,000	30	350,000	675	8,320
Conventional Analytes											
Biochemical oxygen demand	mg/L	81	33,360	5,700	21,700	30,300	54,610	7	29,200	2,310	3,837
Carbonate alkalinity	mg/L	0	20,850	3,050	730	9,500	20,850	470	57,850	2,650	4,214
Chemical oxygen demand	mg/L	40	89,520	8,100	100	51,000	89,250	42	50,450	2,800	4,773
Orthophosphate-phosphorus	mg/L	--	--	--	0.3	130	472	--	--	--	--
Petroleum hydrocarbons	mg/L	--	--	--	--	--	--	--	--	--	--
Sulfate	mg/L	1	1,558	47	20	730	1,826	8	1,400	111	244
Total chloride	mg/L	4.7	2,500	700	47	2,400	2,800	31	5,475	594	786
Total dissolved solids	mg/L	584	44,900	8,955	--	--	42,276	390	31,800	4,890	5,691
Total phosphate	mg/L	0	130	10.1	--	--	--	0.42	8.7	1.2	2.67

Note: -- - No reported value for compound

^a Summary of leachate characteristics based on 20 samples from municipal solid wastes.

^b Chemical composition of landfill leachate.

^c Statistical Summary of Indicator Parameters in MSWLF leachate (and other inorganics).

Table 5-3. Reported background concentrations of metals and SVOCs in soils

	NJDEP ^a	Rutgers ^b	Bradley et al. ^c
Mercury			
Mercury	0.2 mg/kg	--	0.19-0.29 mg/kg
Metals			
Arsenic	5.49 mg/kg	--	3.53-5.63 mg/kg
Beryllium	0.86 mg/kg	--	--
Cadmium	0.5 mg/kg	0.24 mg/kg	1.55 mg/kg
Chromium	11.2 mg/kg	19.9 mg/kg	12.1-23 mg/kg
Copper	32.8 mg/kg	15.6 mg/kg	--
Iron	--	--	--
Lead	113 mg/kg	28.6 mg/kg	262-399 mg/kg
Manganese	283 mg/kg	553 mg/kg	--
Nickel	14.1 mg/kg	20.9 mg/kg	--
Silver	0.16 mg/kg	--	--
Sodium	--	--	--
Thallium	0.07 mg/kg	--	--
Zinc	116 mg/kg	71.3 mg/kg	--
Volatile Organic Compounds			
Benzene	--	--	--
Chlorobenzene	--	--	--
Toluene	--	--	--
Xylene isomers (total)	--	--	--
Semivolatile Organic Compounds			
Anthracene	--	--	351 µg/kg
Benz[a]anthracene	--	--	1319 µg/kg
Benzo[a]pyrene	--	--	1323 µg/kg
Benzo[b]fluoranthene	--	--	1435 µg/kg
Benzo[g,h,i]perylene	--	--	891 µg/kg
Benzo[k]fluoranthene	--	--	1681 µg/kg
Bis[2-ethylhexyl]phthalate	--	--	
Chrysene	--	--	1841 µg/kg
Dibenz[a,h]anthracene	--	--	388 µg/kg
Fluoranthene	--	--	3047 µg/kg
Fluorene	--	--	214 µg/kg
Indeno[1,2,3-cd]pyrene	--	--	987 µg/kg
Phenanthrene	--	--	1838 µg/kg
Pyrene	--	--	2398 µg/kg
PCBs			
Aroclor [®] 1248	--	--	--
Aroclor [®] 1260	--	--	--

Note: -- -- No background value for compound

^a Geometric means reported are background concentrations for NJ urban surface soils (NJDEP 1993b).

^b Arithmetic means reported represent compilation of data over many years by H.L. Motto, Department of Environmental Sciences, Rutgers University (NJDEP 1993b).

^c Bradley et al. (1994) report arithmetic means of background levels for PAHs in New England urban soils. Reported metal values are the ranges of means found in three New England cities.